



School of Energy and Environment

香港城市大學
City University of Hong Kong



11th Asian Aerosol Conference (AAC) 2019

ABSTRACT BOOK

Date:

27 – 30 May 2019 (Monday – Thursday)

Organized by:

School of Energy and Environment,
City University of Hong Kong

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Plenary Talks

Date and Time: 28 May 2019 (Tuesday), 9:15 – 10:15 am

Venue: Wong Cheung Lo Hui Yuet Hall, 5/F, Lau Ming Wai Academic Building, City University of Hong Kong

The Elusive the Ideal Aerosol Measurement

Plenary Speaker: Richard C. Flagan, Division of Chemistry and Chemical Engineering, California Institute of Technology

Abstract: It has been nearly half a century since Sheldon Friedlander (J Aerosol Sci. Vol. 2: 331- 340, 1971) introduced a framework for characterizing aerosol instruments, and identified the ideal as an instrument that would continuously provide perfect resolution of size and chemical composition. In spite of major efforts and advances in aerosol measurement methods, we have not yet approached that ideal. This presentation will examine the progress, some of the challenges that have been encountered, and aspects of ideal measurements that were not considered in that original analysis. Advances include the aerosol mass spectrometers have added a composition dimension to real-time aerosol measurements, but only over a limited size range, from about 40 nm to 1 μm . Differential mobility analyzers (DMAs) have been built that approach the theoretical limit to their resolving power, and have been pushed to ever smaller particles. A new classifier, the opposed migration aerosol classifier (OMAC), changes the scaling that determines when diffusion begins to degrade resolution in mobility analysis and, thereby, increases the dynamic range and the resolution that is, theoretically, attainable. Scanning the voltage in the DMA has enabled much more rapid size distribution measurements than were possible. While many advances toward Friedlander's ideal instrument have been reported, close scrutiny of instrument performance has revealed previously unidentified or under appreciated sources of uncertainty. Detailed simulations of flows, electric fields, and particle trajectories in voltage-scanning DMA (SMPS) measurements have revealed that the instrument response function differs from that predicted by the first-order models that are almost universally used for data analysis, but the computational cost of these simulations was too high to be practical for all DMAs and their full range of operating conditions. Alternate, more cost effective methods for quantitatively determining the response function of the full instrument, i.e., that of the integrated system comprising the DMA, CPC or other detector, and all plumbing. Progress toward the ideal instrument is substantial, but still incomplete. Nonetheless, there is a growing need to add another dimension to Friedlander's analysis; that dimension is geographic resolution. Networks of instruments to provide the community-wide exposure assessment needed for quantifying the links between the ambient aerosol properties and both human health and climate. Measurements in urban air-sheds need to resolve scales of ~ 100 m to capture near roadway effects, while global networks are needed for studies of climate and validation of satellite remote-sensing methods for assessing exposures to particulate matter around the world. Very low cost optical surrogates for PM_{2.5} measurements are increasingly being used to provide some of that data, but many questions have arising regarding the quality and suitability of the data that such sensors deliver. The question of how to develop cost-effective, scientifically-valid measurement strategies to

address specific scientific questions will be examined, and some progress toward such instruments will be presented.

Date and Time: 29 May 2019 (Wednesday), 9:00 – 10:00 am

Atmospheric Aerosols: From Climate to Numerical Weather Prediction

Plenary Speaker: Olivier Boucher (Institut Pierre-Simon Laplace, Paris)

Abstract: Atmospheric aerosols influence the climate system through numerous ways. They do so directly by interacting with shortwave and longwave radiation and by providing nuclei for cloud formation, but also indirectly through their impacts on the global carbon cycle as they modify surface temperature, precipitation, nutrient deposition, the quality of incoming light for terrestrial ecosystems as well as soil acidity. As the emissions of aerosols and aerosol precursors decrease in response to much-needed air quality policies, there is a risk that global warming accelerates as the cooling effect from aerosols wanes. We will review some of the recent progress made in quantifying these climate effects as well as some of the remaining challenges facing the aerosol research community. We will show in particular that quantifying the climate effects of atmospheric aerosols makes it necessary to model accurately their spatial and temporal variability on a relatively small scale. This in turn offers an opportunity to increase the consistency and improve the quality of numerical weather forecasts. Incorporating atmospheric aerosols in numerical weather prediction models requires accurate observations, appropriate data assimilation techniques and raises new challenges in atmospheric radiative transfer.

Date and Time: 30 May 2019 (Thursday), 9:00 – 10:00 am

Multiphase Chemistry in the Indoor Environment

Plenary Speaker: Jonathan Abbatt (Department of Chemistry, University of Toronto)

Abstract: We increasingly spend most of our lives indoors. And yet, the nature of indoor chemistry is not as well studied as that in the outdoor environment. This talk will address the multiphase chemistry that is specific to indoor environments. In particular, the indoor environment is characterized by having a very high surface-area-to-volume ratio that leads to species partitioning strongly to indoor surfaces. Outside of direct sunlight the indoor environment is very dark. For that reason, the major indoor oxidant is ozone, transported from outdoors. Ozone is efficiently lost on surfaces via heterogeneous uptake. Reaction systems that will be addressed specifically in the talk include: ozone reactions with skin and cooking oils, the processes controlling the indoor abundance of HONO, the impact of chlorine bleach washing on the indoor environment, and influence of third-hand smoke on the composition of indoor aerosol.

Parallel Oral Sessions (sorted by Sessions I to VIII)

Parallel Oral Session I

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

28 May 2019 (Tuesday) | 10:45 – 12:00

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Aerosol chemistry (1) Co-chair(s) 1. Lin Du, Shandong University 2. Jialiang Feng, Shanghai University	Lin Du, Shandong University	The reactions between organic and inorganic pollutants on aerosol surface	10:45-11:00	Mr and Mrs Lau Tat Chuen Lecture Theatre (LT-5)
	Jialiang Feng, Shanghai University	Amines in fine particles in Shanghai: composition and seasonal variation	11:00-11:15	
	Beatrix Rosette Mabato, City University of Hong Kong	Reactive Uptake of Glyoxal by Methylammonium-Containing Salts as a Function of Relative Humidity	11:15-11:30	
	Yang Zhou, Ocean University of China	Single particle analysis of amine-containing aerosols at two sites in a coastal city of Qingdao	11:30-11:45	
	Narae Choi, Ewha Womans University	Quantification of the particulate nitrosamines and nitramines in the ambient atmosphere at Seoul, South Korea	11:45-12:00	
Emission inventory (1) Co-chair(s) 1. Jing Wang, ETH Zürich, Institute of Environmental Engineering 2. Yuji Fujitani, National Institute for Environmental Studies	Jing Wang, ETH Zürich, Institute of Environmental Engineering	A number-based inventory of size-resolved black carbon particle emissions by global civil aviation	10:45-11:00	Chan Kei Biu Lecture Theatre (LT-6)
	Yuji Fujitani, National Institute for Environmental Studies	Long-term trend of emission factors of particle number from diesel vehicles: New approach deducing from monitoring data at a traffic intersection	11:00-11:15	
	Fan Zhang, The Hong Kong Polytechnic University	Emission factors and environmental implication of organic pollutants in PM emitted from various vessels in China	11:15-11:30	
	Jorma Jokiniemi, University of Eastern Finland	A novel sampling and dilution system for high-temperature and high concentration aerosols	11:30-11:45	
	Rongzhi Tang, Peking University	Intermediate Volatility Organic Compound Emissions from On-road Gasoline Vehicles in China	11:45-12:00	
Special symposium: Sulfur aerosol chemistry (1) Co-chair(s) 1. Man Nin Chan, The Chinese University of Hong Kong 2. Tengyu Liu, University of Toronto	Man Nin Chan, The Chinese University of Hong Kong	Formation of Inorganic Sulfate in Heterogeneous OH Oxidation of Isoprene Epoxydiol-Derived Organosulfates	10:45-11:00	SAE Magnetics Lecture Theatre (LT-9)
	Tengyu Liu, University of Toronto	Moving beyond the bulk phase: Kinetics of SO ₂ oxidation in sub-micron, deliquesced aerosol particles	11:00-11:15	
	Masao Gen, City University of Hong Kong	Heterogeneous SO ₂ oxidation in sulfate formation by photolysis of particulate nitrate	11:15-11:30	
	Shengrui Tong, Institute of Chemistry, CAS	The formation of secondary sulfate and nitrate particles through multiphase reactions	11:30-11:45	
Special symposium: Atmospheric aging (1) Co-chair(s) 1. Zoran Ristovski, Queensland University of Technology 2. Xue Li, Jinan University	Anthony Wexler, UC Davis	Near-Roadway Neurodevelopmental Disruption	10:45-11:00	Peter Ho Lecture Theatre (LT-10)
	Sonja Muelhopt, Karlsruhe Institute of Technology	Testing of Aerosols for Lung Toxicity by In-Vitro Studies at the Air-Liquid Interface for up to 24 hours	11:00-11:15	
	Erwin W. Karg, Helmholtz Zentrum München	Ageing of Particles by Coagulation: Changes in Regional Lung Deposition	11:15-11:30	
	Zoran Ristovski, Queensland University of Technology	Automated high time resolution measurements of particle bound ROS	11:30-11:45	
	Yan Lyu, Fudan University	Volatility dependence of aerosol size distributions of organic compounds influenced by sources, sampling site and temperature	11:45-12:00	
VOC and secondary precursors (1) Co-chair(s) 1. Jiyi Lee, Ewha Womans University	Vinayak Sinha, Indian Institute of Science Education and Research Mohali (<i>Invited Speaker</i>)	Quantification of BVOC emissions over South Asia for better understanding of Secondary Organic Aerosol and Ozone in urban atmospheric environments	10:45-11:15	Leung Ko Yuk Tak Lecture Theatre (LT-14)
	Huaishan Zhou, Chinese Academy of Sciences, China	Measurement of secondary organic aerosols formation and aging from ambient air in an oxidation flow reactor in Guangzhou, China	11:15-11:30	
	Sheng-Lun Lin, Cheng Shiu University	Flexible Multi-Component Hydrous Diesel Fuels as Circular Green Alternatives for a Non-Road Heavy-Duty Diesel Engine Generator	11:30-11:45	

The reactions between organic and inorganic pollutants on aerosol surface

Lin Du

Environment Research Institute, Shandong University

Siyang Li, Environment Research Institute, Shandong University

Wenxing Wang, Environment Research Institute, Shandong University

Abstract:

Atmospheric aerosols are commonly composed by inorganic and organic mixture and constitute an important fraction of air pollutants. Adsorption of volatile species onto aqueous aerosol surface results in aqueous aerosols coated by organic films. Such organic coatings may affect the physiochemical properties of aerosol particles, which in turn have effects on aerosol nucleation process. The interactions of common atmospheric cations (Ag^+ , Zn^{2+} , Fe^{3+} , Ca^{2+} and Al^{3+}) and anions (Br^- , Cl^- , NO_3^- and SO_4^{2-}) with lipid molecules (fatty acids and phospholipids) were investigated by Langmuir methods and infrared reflection-absorption spectroscopy (IRRAS). The binary mixture, such as fatty acid and phthalate ester, at air-sea water interface was used to model the surface of sea spray aerosol. Surface pressure-area isotherms showed that different ions in the subphase induced the compressed or expanded characteristics of organic monolayers. IRRAS spectra confirmed that inorganic ions mixed with lipid molecules changed the surface properties of aqueous aerosols. Formation of different coordination types of carboxylates at the air-water interface altered the dissolution and partitioning behavior. The miscibility and stability of mixed films were dependent on the composition of mixture. Sea salts improved the stability and lifetime of mixed fatty acid and phthalate ester film on the aerosol surface. The surface organization of organic film and the change of surface to bulk partitioning may have significant impacts on the evaporation of water vapor, droplet growth and the transport of atmospheric pollutants. Our study combined the surface structure with surface properties of aqueous aerosols and established an efficient method for further understanding of organic coating formation mechanism and their potential atmospheric implications.

Amines in fine particles in Shanghai: composition and seasonal variation

Jialiang Feng

Shanghai University, China

Jiqi Zhu, Wenwen Mao

Abstract:

Amines are important nitrogen-containing organic compounds in the atmosphere. They might play important role in the formation and transformation of atmospheric particles. To investigate the concentration and distribution of amines in fine particles in Shanghai, PM_{2.5} samples collected in 2016 at two sites in Shanghai were analyzed with GC-MS for six low molecular weight amines: methylamine (MA), dimethylamine (DMA), ethylamine (EA), diethylamine (DEA), propylamine (PA) and butylamine (BA). The total concentration of these amines ranged from 6.1 ng/m³ to 138.0 ng/m³ with an average concentration of 54.2 ng/m³. MA, DMA and DEA were the dominant amines, accounting for more than 90% of the total amines. The concentration of amines at the rural site was higher than that at the urban site, suggesting that the biogenic sources would be more important for the atmospheric amines in Shanghai. Higher concentration of amines was found in summer, followed by spring, autumn and winter. Moderate correlation was found between the concentration of amines and PM_{2.5}, also the main ionic species, especially in winter, suggesting that absorption of the particles might be an important way in the formation of particulate amines.

Reactive Uptake of Glyoxal by Methylammonium-Containing Salts as a Function of Relative Humidity

Beatrice Rosette Mabato

School of Energy and Environment, City University of Hong Kong

Masao Gen, School of Energy and Environment, City University of Hong Kong

Yangxi Chu, School of Energy and Environment, City University of Hong Kong

Chak Chan, School of Energy and Environment, City University of Hong Kong

Abstract:

The aqueous phase reactions between glyoxal (Gly) and methylammonium salts have been proposed to produce brown carbon (BrC). Yet, studies on their heterogeneous reactions and the effect of relative humidity (RH) on BrC formation are scarce. Here, we report the reactive uptake of Gly by methylammonium chloride, sulfate, and nitrate (MeACl, MeAS, and MeAN, respectively) particles as a function of RH using in-situ Raman/fluorescence spectroscopy. Bulk-phase reactions of premixed solutions of Gly and methylammonium salt were also examined using UV/vis spectroscopy. Results of bulk-phase reactions show that the first-order reaction rate constants of BrC formation are about $7.0 \times 10^{-7} \text{ s}^{-1}$ regardless of salt type. For the particle-phase reactions, in-situ Raman analysis, which was limited to MeAS and MeAN particles due to the Raman inactive Cl anion of MeACl, yielded the first-order rate constants of BrC formation based on the fluorescence emissions from BrC. Similar to the bulk-phase reactions, the estimated particle-phase first order reaction rate constants of MeAS and MeAN particles are comparable as indicated by the comparable effective Henry's law constants of Gly in the two salt particles at a particular RH. The particle-phase rate constants increase from 8.66×10^{-6} to $1.05 \times 10^{-4} \text{ s}^{-1}$ for MeAS and from 1.06×10^{-5} to $7.29 \times 10^{-5} \text{ s}^{-1}$ for MeAN when RH decreases from 80 to 30%. They are higher than the bulk-phase values, likely due to the "salting-in" effect at higher salt concentrations. The "salting-in" effect can explain the enhanced formation of BrC with decreasing RH. In contrast to the reactions between Gly and ammonium salts (Environ. Sci. Technol., 2018, 52, 6903–6911), the promoted dehydration reactions do not play a significant role in the enhanced BrC formation likely due to the higher hygroscopicity of methylammonium salts.

Single particle analysis of amine-containing aerosols at two sites in a coastal city of Qingdao

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Abstract:

Amines, one important type of organic nitrogen, are ubiquitous atmospheric bases, and play a critical role in atmospheric chemistry. The marine amines, impacted significantly by blooms, are known to be an important source. One of the pivotal factors affecting the formation of particular amines is the gas/particle partitioning. However, most of the previous studies focused on bulk measurements with poor time resolution, and thus were difficult to access the detailed process of gas/particle partitioning.

In the present study, we conducted single particle measurements of amine-containing aerosols at both a coastal roadside site (LQH) and an urban site (OUC) in Qingdao. Campaigns were launched at the two sites from August to early September respectively, when the biogenic activity of Yellow sea is changing from high to low. A total of 679,541 (at LQH) and 1,729,756 (at OUC) particles with both positive and negative mass spectra were recorded, in which 37.9% and 9.2% were detected as amine-containing aerosols, including mainly trimethylamine (TMA, m/z 59[N(CH₃)₃]⁺) and diethylamine (DEA, m/z 74 [(C₂H₅)₂NH₂]⁺). At the coastal roadside site, 36.4% of the particles were identified as TMA, mixed mainly with black carbon and sulfate. In contrast, at the urban site, TMA dominated at the late August and DEA was much more abundant in the early Sep. Combined with the backward trajectories analysis, the results strongly suggest that marine source is likely to dominate TMA formation. With the in-situ

measured hourly particle number intensity, different diurnal variations were observed for TMA and DEA. At the roadside site, a larger number of TMA particles was consistently observed during nighttime when the Relative Humidity was very high. The sharp increase of TMA often associated with an sulphuric acid ion cluster peak m/z -195[H(HSO₄)₂-], an indicative of particle acidity. These findings indicate that ambient water content and aerosol acidity play critical roles in TMA formation. While for DEA, we observed a sharp peak in the early morning around 5:00 to 6:00am, which may associate with the early biomass burning. In the OUC site, however, amines did not show obvious diurnal variation. We only frequently detected the morning and an additional night peak of DEA. Considering amines mix with more variable OC, ammonium and nitrate at this site, it is conceivable that complex sources of background aerosols, including the abundant ambient NH₃ and acidic aerosols would significantly influence the mixing process of these amine particles. This was future supported by the results of Art-2a classifications. Overall, the present analyses could help to improve our understanding in potential partitioning of amine containing particles in the coastal site aerosols.

Quantification of the particulate nitrosamines and nitramines in the ambient atmosphere at Seoul, South Korea

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Yun Gyong Ahn, Korea Basic Science Institute

Ji Yi Lee, Ewha Womans University

Yong Pyo Kim, Ewha Womans University

Abstract:

Nitrosamines and nitramines are the groups of chemical compounds with the general structure containing nitroso (N-NO) and nitro (N=O) functional group, respectively, and they have been suspected as carcinogens. Nitrosamines and nitramines in the atmosphere can be emitted from primary emission sources such as industrial use, vehicular exhaust, and other processes like tobacco smoking or cooking. They can be also generated from the atmospheric reactions and removed by photolysis. Simultaneous analysis of nitrosamines and nitramines is necessary to understand the major sources of nitrosamines and nitramines in the ambient atmosphere.

Simultaneous analysis of 7 nitrosamines (nitroso dimethylamine, nitroso diethylamine, nitroso dipropylamine, nitroso dibutylamine, nitroso morpholine, nitroso piperidine and nitroso pyrrolidine) and 3 nitramines (methylnitramine, dimethylnitramine and diethylnitramine) in the atmospheric particulate matter with an aerodynamic diameter of less than or equal to a nominal 2.5 μm (PM_{2.5}) at Seoul during winter (2018.01~2018.02) was carried out by using gas chromatography/tandem mass spectrometry (GC/MS-MS). The ambient levels of nitrosamines and nitramines were 9.74 ± 17.00 ng/m³ and 0.67 ± 0.53 ng/m³, respectively. Total concentrations of nitrosamines and nitramines were highly correlated with PM_{2.5} ($R=0.6626$; significant at the level of 0.01 (2-tailed)). Among nitrosamines and nitramines, nitroso dimethylamine and dimethylnitramine had higher portions among the total concentrations of nitrosamines and nitramines, respectively. When high PM_{2.5} concentrations episodes occurred, these two compounds were highly correlated ($R=0.8811$; significant at the level of 0.01 (2-tailed)). Major sources of the observed nitrosamines and nitramines are to be investigated using the correlation and multivariate analysis based on the ambient concentrations of nitrosamines, nitramines, other carbonaceous organic, inorganic compounds and meteorological parameters which were simultaneously measured.

A number-based inventory of size-resolved black carbon particle emissions by global civil aviation

Jing Wang

ETH Zürich, Institute of Environmental Engineering

Abstract:

With the rapidly growing global air traffic, the impacts of the black carbon (BC) in the aviation exhaust on climate, environment and public health are likely rising. The particle number and size distribution are crucial metrics for toxicological analysis and aerosol-cloud interactions. However, most of the current inventories only contain gaseous emissions; few of them have BC mass data and the number emission is scarcely available. We developed the first size-resolved BC particle number emission inventory for the global civil aviation based on the recent standardized BC measurements, the mass-based aviation emission database, the global dataset of annual 27 million scheduled flights, and thousands of flight surveillance records. The BC particle number emission was estimated to be $(10.9 \pm 2.1) \times 10^{25}$ per year and $(6.06 \pm 1.18) \times 10^{14}$ per kg of burned fuel. The aviation BC number emission amounts to about 1.3% of the total ground anthropogenic emissions, and is equivalent to nearly 11% of the road transport emission in Northern America, only about 1.3% in Asia, and about 3.6% on global average. The total global aviation emitted BC particles approximately follow a lognormal distribution with a geometric mean diameter of 31.99 ± 0.8 nm and a geometric standard deviation of 1.85 ± 0.016 .

Long-term trend of emission factors of particle number from diesel vehicles: New approach deducing from monitoring data at a traffic intersection

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Shuichi Hasegawa, Center for Environmental Science in Saitama

Yoshinori Kondo, National Institute for Environmental Studies

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Abstract:

To elucidate the effect of mitigation strategies that could reduce the impact of traffic on air pollution levels, it is important to conduct the long-term observations of pollutants in the environment for detecting trends. Besides data of long-term concentrations of pollutants, information of traffic volume as a function of type of vehicle (exhaust displacement, which emission regulation meet) are also needed. The emission factor is one of the key parameters that enable to assess whether the improving of the quality of exhausts and is an essential parameter to predict atmospheric particle number (PN) concentrations by dispersion models. Although the emission factors can be obtained studies on emissions from specific types of vehicles under controlled conditions such as constant speed or load, but it provide very limited information (Kumar 2011). Therefore, determination of emission factors for mixed fleet of vehicles under real-world driving conditions is also needed.

This study showed new approach to determine the PN emission factor (EFPN) for mixed fleet of diesel trucks at the traffic intersection in a metropolitan area in Japan. Also, long-term trend of EFPN (2005-2016 in each year) and EFPN with respective to regulation year were revealed. EFPN was obtained by long-term PN and PM monitoring data in combination with the tailpipe PM mass emissions. The tailpipe PM mass emissions were estimated from traffic volumes as functions of emission regulation year and gross weight of trucks and giving emission factor of each category.

The mixed fleet EFPN ($D_p = 10 - 100 \text{ nm}$) in each year during 2005 - 2016 were estimated as $1.1 - 4.9 \times 10^{14} \text{ km}^{-1} \text{ veh}^{-1}$ and $0.5 - 7.4 \times 10^{14} \text{ km}^{-1} \text{ veh}^{-1}$, in winter and summer, respectively, at ca. 25% HDV fraction under urban driving conditions (0 - 50 km h⁻¹). For long-term trend, decrease rates in winter and in summer were $1.3 \times 10^{13} \text{ km}^{-1} \text{ veh}^{-1} \text{ year}^{-1}$ and $2.2 \times 10^{13} \text{ km}^{-1} \text{ veh}^{-1} \text{ year}^{-1}$,

respectively, for a period of 2005 - 2016. Previous studies (Wang et al., 2010; Krecl et al., 2017) were shown that decrease rates were $9.3 \times 10^{12} \text{ km}^{-1} \text{ veh}^{-1} \text{ year}^{-1}$ and $3.7 \times 10^{13} \text{ km}^{-1} \text{ veh}^{-1} \text{ year}^{-1}$, respectively, and the values obtained in this study was within this range.

EFPN for vehicle with respect to emission regulation year was also determined using the positive matrix factorization model by applying to environmental data. EFPN of vehicles that meet 1988-1990 regulation was the highest as $10^{16} \text{ km}^{-1} \text{ veh}^{-1}$ and those meet the latest emission regulation (2009-2010) was the lowest as $1.4 \times 10^{13} \text{ km}^{-1} \text{ veh}^{-1}$. The EFPN of latest regulation vehicles was one order of magnitude lower than the mixed fleet emission factor as of 2016. Therefore, when all vehicles will be replaced by vehicles that meet latest emission regulation, it is expected that the atmospheric PN concentration will be reduced one order of magnitude.

References

Kumar, P. et al., J Aerosol Sci, 42, 580-603, 2011.

Krecl, P. et al., Atmos. Environ., 165, 155-168, 2017.

Wang, F. et al., 10, 2745-2764, 2010.

Emission factors and environmental implication of organic pollutants in PM emitted from various vessels in China

Fan Zhang

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Yingjun Chen, Fudan University, China

Abstract:

Organic pollutants emitted from ship exhaust have significant health and air quality impact in coastal areas; their profiles are also in urgent need. Studies on organic pollutants from ships is still rare, especially in China. Therefore, 21 PAHs and 29 n-alkanes in PM emitted from 15 ships with different types and fuels under different operating modes in China were tested in this study. The results showed that: Identified organic matters accounted for 0.15% to 23.3% of PM. Fuel-based emission factors (EFs) for \sum 16PAHs ranged from 0.095 to 5.80 mg (kg fuel)⁻¹, with low-engine-power fishing boats and HFO training ship had higher values compared with light diesel vessels. EFs for \sum n-alkanes ranged from 5.22 to 1,589 mg (kg fuel)⁻¹, with low-engine-power fishing boats had higher values compared with other vessels. The dominant PAHs were medium molecular weight components of Pyr, Flua, Phe, and Chr. N-alkanes from C15 to C33 accounted for more than 97% of the total n-alkanes. Ratios of typical PAHs and n-alkanes parameters in this study showed typical diagnostic characteristics of oil combustion source. Profiles and diagnostic characteristics of PAHs together with n-alkanes could provide a more precise source apportionment result in the future. Besides, PAHs in PM emitted from ships inferred non-ignorable health influence.

A novel sampling and dilution system for high-temperature and high concentration aerosols

Jorma Jokiniemi

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Jani Leskinen, University of Eastern Finland

Miika Kortelainen, University of Eastern Finland

Jarkko Tissari, University of Eastern Finland

Mika Ihalainen, University of Eastern Finland

Jarno Ruusunen, Venacontra Ltd.

Olli Sippula, University of Eastern Finland

Abstract:

Sampling of aerosols from high temperatures is needed in order to get experimental data on aerosol formation and transformation in combustion systems or other high temperature processes. However, sampling from high temperature processes is usually very challenging due to high particle concentrations and/or condensable vapors in the sample and usually high temperature gradients occurring in the sampling system. In this work a quench-diluting sampling system, based on porous tube dilution, was developed and tested. The aim of the sampling system is to quench the sample, by decreasing temperature and concentrations rapidly, to freeze the chemical reactions and coagulation. We present the sampling/dilution probe during its utilization in several biomass-fired units under different temperature regions.

The Diluting Aerosol Sampling System (DAS) consists of a porous tube diluter in which dilution gas is supplied through a porous wall and mixed with the sample. The porous tube diluter is followed by a large-orifice ejector diluter, after which the sample is stabilized and conditioned to be divided for selected aerosol analyzers.

The measurements have been carried out for engines, vehicles, marine applications and combustion. In the high-temperature sampling (HDAS) the diluting probe was water cooled and operated with varying dilution ratios, ranging from 14 to 120. The diluted sample was measured using a Scanning Mobility Particle Sizer, TaperEd Oscillating Microbalance (TEOM) and an Electrical Low Pressure Impactor. In addition, samples for electron microscopy and chemical analyses were collected. Multicomponent thermodynamic equilibrium models (Factsage and HSC softwares) were used for interpreting the experimental results.

PM₁ of the wood chip fired grate combustion reactor was analysed to consist mainly of potassium sulfate, potassium chloride and smaller amounts of zinc oxide, sodium salts, EC and OC (Kortelainen et

al., 2015). The particle size distributions (PSD) measured after the heat exchanger of the wood-fired grate combustion reactor ($T < 200$ oC) were unimodal and stable towards changes in the dilution ratio. The dilution corrected number concentrations varied in the range $1-3 \times 10^8$ particles/cm³. In contrast, the PSDs measured directly from the combustion chamber at about 800-900 oC were very sensitive to dilution ratio, indicating that aerosol dynamic processes (condensation, coagulation, nucleation) were still ongoing in the sampling position and continued in the probe. The very high number concentration and small particle size is consistent with thermodynamic considerations, indicating that from the major chemical species only zinc oxide and possibly alkali sulphate (Sippula et al., 2012) is in the condensed phase and should exist as freshly formed seed particles at this temperature.

The results show that the HDAS high-temperature sampling system can be used for obtaining detailed and valuable information on the formation and dynamics of aerosols at high temperatures.

Kortelainen, M. et al. (2015) Fuel, 143, 80-88.

Sippula, O., Koponen, T. and Jokiniemi, J. (2012) Aerosol Sci. Technol. 46, 1151-1162.

Intermediate Volatility Organic Compound Emissions from On-road Gasoline Vehicles in China

Rongzhi Tang

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Quanyang Lu, Carnegie Mellon University

Rui Tan, Peking University

Hui Wang, Peking University

Kai Song, Peking University

Kefan Liu, Peking University

Wenbin Zhang, Tsinghua University

Zhou Zhang, Tsinghua University

Shijin Shuai, Tsinghua University

Hongming Xu, Tsinghua University

Allen.L Robinson, Carnegie Mellon University

Song Guo, Peking University

Abstract:

China is in a high-growth state with soaring increase in vehicles. The rapid increase (~26 fold in 25 years) in on-road vehicle fleet in China made it a great burden on air quality and human health. Previous studies showed that apart from the acknowledged reactive VOCs such as light aromatics, alkenes and aldehydes, intermediate volatility organic compounds (IVOCs) could not be ignored in the emission inventory. It can contribute as much, or much higher to secondary organic aerosol (SOA) compared with VOCs. However, few studies focused on IVOCs emissions from Chinese light-duty gasoline vehicles which greatly limited our understanding on contributions of gasoline vehicles to SOA formation in China. Considering the unique atmospheric conditions and different fuel compositions of China, a full sculpture of IVOCs emission should be carried out. In this study, speciated and unspeciated IVOCs emissions from an in-use gasoline vehicle based on direct inject engine were collected during chassis engine dynamometer testing. IVOCs were quantified using gas chromatography/mass spectrometry analysis coupled with Gerstel thermal desorption sample extraction and injection system collected from a constant volume sampler. About 20% of the IVOCs could be specified with others existing as unspecified IVOCs. The unspecified IVOCs could be divided into two lumps, including unspeciated branched alkanes and cyclic compounds. The specified and unspecified IVOCs were then divided into 11 retention-time based bins to study its SOA formation ability. We test the influence of different conditions i.e. cycles,

fuel compositions and starting mode on IVOCs emissions. The mass, volatility and chemical speciation of IVOCs from different conditions were also examined. The relationships between IVOCs, POA and hydrocarbons were investigated. Our results demonstrated that IVOCs are a great class of SOA precursors for China and provide observational constraints on IVOC emission factors and chemical specification to facilitate their inclusion into atmospheric chemistry models. We also evaluate emission factors of ethanol-added gasoline to provide an environmentally-based prospective of ethanol-added gasoline in future market which would provide effective evidence for policy making.

Formation of Inorganic Sulfate in Heterogeneous OH Oxidation of Isoprene Epoxydiol-Derived Organosulfates

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Abstract:

Multiphase chemistry of epoxydiols formed from isoprene oxidation yields the most abundant organosulfates (i.e., methyltetrol sulfates) detected in atmospheric aerosols. However, chemical stability of these organosulfates remains unclear. We investigate the heterogeneous oxidation of aerosols consisting of potassium 3-methyltetrol sulfate ester ($C_5H_{11}SO_7K$) by gas-phase hydroxyl radical (OH) through studying the oxidation kinetics and reaction products. Real-time molecular composition of the aerosols is obtained by using a Direct Analysis in Real Time (DART) ionization source coupled to a high-resolution mass spectrometer. Aerosol mass spectra only show increases in the intensity of bisulfate ion (HSO_4^-) after oxidation, suggesting the absence of functionalization processes that is likely attributable to the steric effect of substituted functional groups (e.g. methyl, alcohol and sulfate groups) on peroxy-peroxy radical reactions. Potassium 3-methyltetrol sulfate ester likely decomposes to form volatile fragmentation products and aerosol-phase sulfate radical anion ($SO_4^{\bullet-}$). $SO_4^{\bullet-}$ subsequently undergoes intermolecular hydrogen abstraction to form HSO_4^- . These processes appear to explain the compositional evolution and the formation of inorganic sulfates of the 3-methyltetrol sulfate ester during heterogeneous OH oxidation.

Moving beyond the bulk phase: Kinetics of SO₂ oxidation in sub-micron, deliquesced aerosol particles

Tengyu Liu

University of Toronto

Jonathan P.D. Abbatt, University of Toronto

Abstract:

Sulfate aerosol is a major component of fine particulate matter and has important impacts on air quality, climate, and human and ecosystem health. However, current atmospheric models that include gas- and aqueous-phase oxidation pathways of SO₂ generally underestimate the sulfate production rate during severe haze events. The reaction rate coefficients for aqueous-phase oxidation pathways in these models have been determined in bulk solution, which may not be applicable to the wet aerosol particles with three to five orders of magnitude lower water content and very much higher ionic strength than that of fog or cloud droplets. Here, we utilize a flow tube system that allows us to directly investigate, to our knowledge for the first time, the aqueous phase oxidation of dissolved SO₂ by H₂O₂, O₃, NO₂, and O₂ catalyzed by transition metal ions in sub-micron, deliquesced aerosol particles at two different aerosol pH values (2.8 and 5.7). The pH-, SO₂-, and oxidant concentration-dependent sulfate formation rates are determined for different oxidation pathways and compared to the modeled sulfate formation rates from bulk phase studies. The relative roles of different oxidation pathways are elucidated for severe haze events. Updating the current models with kinetic data for sulfate formation in sub-micron aerosol particles will improve air quality and climate simulations.

Heterogeneous SO₂ oxidation in sulfate formation by photolysis of particulate nitrate

Masao Gen

City University of Hong Kong

Dan Dan Huang, Shanghai Academy of Environmental Sciences

Yongjie Li, University of Macau

Chak Chan, City University of Hong Kong

Abstract:

Heterogeneous oxidation of sulfur dioxide (SO₂) is suggested to be one of the most important pathways for sulfate formation during extreme haze events in China. Yet, the exact mechanism remains highly uncertain. We propose a much less explored pathway for aqueous-phase SO₂ oxidation to form particulate sulfate by NO₂ and OH radicals produced from photolysis of particulate nitrate. Reactive uptake experiments of SO₂ by ammonium nitrate particles under UV irradiation show the measured SO₂ uptake coefficients of $\sim 10^{-5}$. Model calculations of sulfate production rates, comparing known oxidation mechanisms by O₃, NO₂, H₂O₂, and transition metal ions, and the nitrate photolysis mechanism suggest that the nitrate photolysis pathway could contribute significantly to the overall sulfate production at pH = 4 to 6. The present study provides a new insight into the current debate on sulfate production pathways under typical haze conditions in China.

The formation of secondary sulfate and nitrate particles through multiphase reactions

Shengrui Tong

Institute of Chemistry, CAS

Abstract:

Aerosol pollution in the atmosphere has become a critical environmental problem due to the rapid expansion and urbanization, which has led to frequent incidents of the haze weather. The essence of haze weather is atmospheric pollution of fast formation of fine particulates, contained sulfate, nitrate, ammonium, and organic compounds. Heterogeneous reactions, giving important contribution to the formation of secondary particles, have been attracting long-term interest for scientists. However, the physicochemical processes of pollutants during the haze evolution, the migration and transformation rules among different phases as well as the mechanisms of the gas-liquid-solid multiphase reactions remain largely unknown. Moreover, it is not characterized reasonably in the numerical model during the processes of multiphase reactions, including the formation and removal mechanisms of the sulfate and nitrate and their precursors as well as the influence of changes in physical and chemical properties of aerosols. Therefore, according to the situation of the coal-motor vehicle exhaust coexist pollution in our country, we devote to understand and illuminate the kinetics and mechanism of multiphase reaction at a molecular level. The influence mechanism of particle diameter, mixed particles on heterogeneous formation of sulfate and nitrate at different RH was obtained. The effect of the water adsorbed on the surface were investigated in detail, the factors on the kinetics sulfate and nitrate formation were quantified, and the formation and growth of sulfate and nitrate by the heterogeneous pathway is explored. We found that the water adsorbed on the surface could improve the formation of nitrate and sulfate. Furthermore, different RH condition can affect the product. We hope to find the key factors for the fast formation of secondary particles through these investigations.

Near-Roadway Neurodevelopmental Disruption

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UC Davis

Keith Bein, UC Davis

Elizabeth Berg, UC Davis

Kelley Patten, UC Davis

Anthony Valenzuela, UC Davis

Jill Silverman, UC Davis

Pamela Lein, UC Davis

Abstract:

Recent epidemiological studies have linked traffic-related air pollution (TRAP) to increased risk of adverse neurodevelopmental outcomes, including psychomotor deficits, cognitive impairments, and autism. In addition, in vivo and in vitro studies have shown that individual components of TRAP can alter neuroinflammation, increase neurotransmitter levels, and increase neurogenesis. However, TRAP exposures are challenging to reproduce in laboratory settings, and the mechanisms by which TRAP modulates neurodevelopment remain unclear. To address these issues, we exposed male and female Sprague-Dawley rats to real-time TRAP, using an exposure facility that samples air directly from a highway tunnel in the Bay Area of California used by both light- and heavy-duty vehicles. TRAP and filtered air (FA) samples were collected for 24 hours once every third day, and a subset of these were analyzed for particulate matter mass, organic and elemental carbon composition, and elemental composition. Gas phase samples were collected monthly on sorbents and analyzed for molecular organics. Rats were exposed to TRAP or filtered air (FA) from gestational day 15 to postnatal day 50. Following exposure, the brains from the rats were analyzed for markers of neurodevelopmental disruption, including behavioral changes, microglial infiltration, reactive astrogliosis, neurogenesis using immunohistochemistry, ventricular volume and extra-cerebral volume. These data suggest that exposure of the developing brain to TRAP disrupts normal neurodevelopment. This work was supported by the NIEHS (grants R21 ES025570 and P30 ES023513), NIA (grant P30AG010129), NICHD (grant U54 HD079125) and NIMH (T32 MH112507).

Testing of Aerosols for Lung Toxicity by In-Vitro Studies at the Air-Liquid Interface for up to 24 hours

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Silvia Diabate, Karlsruhe Institute of Technology KIT

Christoph Schlager, VITROCELL Systems GmbH

Marco Dilger, Karlsruhe Institute of Technology KIT

Markus Berger, VITROCELL Systems GmbH

Tobias Krebs, VITROCELL Systems GmbH

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Hanns-Rudolf Paur, Karlsruhe Institute of Technology KIT

Abstract:

The state of the art of studying the health effects of aerosols in vitro is based on submerged exposure of collected particulate matter, suspended in culture medium. However, this method neglects the gas phase including their interactions with particles and cells. It may change the properties of the investigated particles and does not represent the actual process in the human lung [1].

Exposure at the Air-Liquid Interface (ALI) avoids these disadvantages, but requires a comprehensive system to guarantee reproducible conditions. Therefore, KIT and VITROCELL Systems developed a fully automated ALI exposure station [2]. The exposure station offers a complete measurement system for parallel exposure of up to 24 human lung cell cultures towards gases, nanoparticles and complex mixtures such as combustion aerosols. The aerosol flow, temperature, and humidity are adjusted to the conditions resembling the human lung. An internal negative control using humidified synthetic air is also implemented and the particle dose per time can be increased by electrostatic particle deposition. The particle mass per area deposited by diffusional as well as by electrostatic mechanism is monitored online using a quartz crystal microbalance [3]. Additionally, a new tool to reproducibly expose sample grids for transmission electron microscopy was developed and applied [4]. Image evaluation of TEM images delivers dose information with respect to the spatial distribution and the agglomeration state of the deposited particles. Applications of the ALI exposure station are environmental atmospheres and technical emission sources like ship diesel exhaust as reported by Oeder et al [5] and Sapcariu et al [6].

Long-term stability of A549 lung cells was examined for exposure times up to 24 hours by exposing A549 cell cultures towards clean air as well as towards airborne titanium dioxide and copper oxide nanoparticles. Dose measurement data and biological responses as viability (AlamarBlue assay), cytotoxicity (LDH release), and release of cytokines during long-term exposure are reported.

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Ageing of Particles by Coagulation: Changes in Regional Lung Deposition

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Abstract:

Aerosol particles undergo ageing processes while being transported in the atmosphere. Besides ageing by UV radiation, by condensation and evaporation of gaseous components and by chemical processes due to internal mixing, the coagulation of freshly emitted particulates with other airborne particles is one of the main processes for modification of particle properties during atmospheric transport. It reduces the number concentration, shifts the particle size distribution and changes the chemical composition. Therefore, the inhalation of freshly emitted and coagulation-aged particles is suspected to imply different outcomes.

In a model study using the hygroscopic lung deposition model (HPLDB) of Ferron [1, 2], particle lung deposition is estimated for various aerosol species e. g. freshly emitted aerosols from ship diesel, for wood smoke and for aged urban and background aerosol. Data show that number- and mass-deposition in different regions of the respiratory tract are modified considerably by the ageing process and should therefore be taken into account for the interpretation of toxicological and epidemiological studies.

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Automated high time resolution measurements of particle bound ROS

Professor Zoran Ristovski

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Abstract:

The oxidative stress hypothesis is aimed at explaining the link between particulate matter (PM) and adverse health effects. PM generated through combustion processes introduce a group of free radicals known as reactive oxygen species (ROS) to cells when inhaled. These ROS impede cell function creating oxidative stress, which can lead to inflammation and cell death.

To investigate this hypothesis, instrumentation to accurately measure the ROS content (oxidative load) of PM is essential. Several systems have been developed to address this, using both commercially available and in-house designed instrumentation coupled with either the DCFH-DA or DTT probes (Fuller et al. 2014).

These systems are limited in effectiveness by probe reaction times, time resolution, sensitivity, and ease of use. For this reason, a new ROS probe, BPEAnit profluorescent nitroxide (Stevanovic et al. 2012), was combined with a purpose built particle collector and miniature flow-through fluorimeter to create the particle into nitroxide quencher (PINQ) (Brown et al. 2018). This instrument has a faster response time and lower limit of detection than any other instrument presented in the literature.

The PINQ collects PM for oxidative load measurements with > 97% efficiency and a cut-off size of >20 nm, regardless of chemical composition. This is achieved through a custom made steam collection device known as the insoluble aerosol collector (IAC). Aerosol is continuously sampled, grown into water droplets, and collected into a solution of DMSO and the BPEAnit probe inside a vortex collector. The liquid sample is then debubbled and passed through the fluorimeter for quantification of ROS.

This system was coupled with a flow switching assembly to alternate between total and gas phase samples, with the difference in fluorescence response being proportional to particle phase ROS. The system is fully automated, with a time resolution as low as one minute and software providing real time data analysis. In this configuration the instrument has operated for a total of over 3 months over 3 separate campaigns in the Chinese cities of Guangzhou, Heshan, and Beijing.

Data will be presented on high time resolution diurnal profiles of PM oxidative potential in the aforementioned cities. Observations of pollution events and correlations with other PM and gas pollutants will also be discussed.

Volatility dependence of aerosol size distributions of organic compounds influenced by sources, sampling site and temperature

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Abstract:

Aerosol size distribution of organic compounds is of great importance in regulating their atmospheric deposition and respiratory deposition. However, it is highly uncertain in ambient environment. In this study, a series of organic compounds in four classes including polycyclic aromatic hydrocarbons (PAHs), oxygenated PAHs (O-PAHs), n-alkanes, polybrominated diphenyl ethers (PBDEs), ranging from volatile organic compounds (VOCs) to extreme low volatile organic compounds (ELVOCs), were quantified in size-resolved particles collected in urban Shanghai atmosphere during a one-year sampling using a gas chromatograph (GC) coupled to a tandem mass spectrometer (GC-MS/MS) and a two-dimensional gas chromatography equipped with a flame ionization detector (GC×GC-FID). The main objectives were to characterize organic fractions in size-resolved particles (with a focus on PAHs, O-PAHs, n-alkanes and PBDEs) and relate their size distributions to their volatilities. A high positive correlation was observed between size distribution (represented by geometric mean diameters, or GMDs) and volatility (represented by saturation mass concentration, C^*). It might be resulted from that the evolution of size distribution was volume-controlled with slower reactive uptake in ambient environment. Regression analysis of GMDs versus logarithmic values of C^* ($\log C^*$) gives slope and interception values of 0.15 ± 0.02 and 1.99 ± 0.07 , respectively. The higher ambient temperature will lead to higher slope values, and the interception values will be lower for the anthropogenic derived organic compounds collected background sites. Further dry deposition and respiratory deposition modelling of size-resolved particles showed positive correlation ($p < 0.01$) between deposition velocity/efficiency and GMD and volatility of the organic compounds, indicating the longer residence time and the greater ability of penetrating into lower respiratory tract for lowly volatile organic compounds.

Quantification of BVOC emissions over South Asia for better understanding of Secondary Organic Aerosol and Ozone in urban atmospheric environments

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Abstract:

Biogenic Volatile Organic Compound (BVOC) emissions such as isoprene and monoterpenes are highly reactive and can fuel secondary organic aerosol and surface ozone formation on rapid timescales (few hours) with significant impacts for both regional air quality and climate. In particular, when such emissions occur near or within cities, they mix in with anthropogenically emitted compounds like nitrogen oxides resulting in secondary organic aerosol compounds and yields which can differ markedly from oxidation chemistry that occurs in pristine forested atmospheric environments. In this paper, experimental results pertaining to emission rates of isoprene and monoterpenes using dynamic plant cuvettes and proton transfer reaction mass spectrometry from some major trees being grown widely in South Asia as part of silviculture and agroforestry practices will be presented. The experimental results will then be discussed from the perspective of current parametrizations employed in MEGAN (Model of Emissions of Gases and Aerosols from Nature), which is the most widely employed BVOC emission model in Chemical Transport Models, with suggestions for further improvement for such model simulations over South Asia. Finally, the implications for air quality and atmospheric chemistry from the point of both SOA and ozone, will be delineated.

Measurement of secondary organic aerosols formation and aging from ambient air in an oxidation flow reactor in Guangzhou, China

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Abstract:

Oxidation flow reactor (OFR) has been increasingly applied to laboratory and field studies on SOA oxidation with advantages on its capability of fast varying oxidants concentration and less wall losses of semivolatile organic compounds (SVOCs). To investigate the SOA formation process from ambient precursors, an in-situ OFR (OH radicals) was deployed in a synthetic field study at an urban site in Guangzhou during autumn of 2018. The oxidant OH radical in OFR was generated through photolysis O₃, H₂O by UV lamps at a wavelength of 185 and 254 nm (OFR185 mode). An empirical equation based on O₃, H₂O and external OH reactivity was used to estimate the OH exposure, with constraints from calculated OH exposure from the real decay of Benzene, Toluene and SO₂. The OH exposure in the reactor ranged from 10¹¹ molec.cm⁻³s to 10¹³ molec.cm⁻³s, which equals to few hours to two months of photochemical age, by assuming 24h average ambient OH concentrations of 1.5×10⁶ molec.cm⁻³s, was achieved. OFR output was analyzed by state-of-the-art gas and aerosol instruments including a High-Resolution Aerosol Mass Spectrometer (HR-AMS), a scanning-mobility particle sizer (SMPS), and a Proton-Transfer Reaction Time-of-Flight Mass Spectrometer (PTR-ToF-MS). SOA enhancement (OA from output of OFR-ambient OA) peaks and plateaus around 3-6 days of OH aging, then decreases at higher aging, indicating shifting contributions of functionalization vs. fragmentation. Higher SOA enhancement in OFR was observed during polluted days than that from clean days. The formed SOA after OFR cannot be fully explained by the detected VOCs decay with chamber yield applied, suggesting that S/IVOCs play a significant role in the SOA formation in Guangzhou urban areas. Finally, SOA as a function of OH exposure in this study was compared with other ambient OFR studies in urban and biogenic areas.

Flexible Multi-Component Hydrous Diesel Fuels as Circular Green Alternatives for a Non-Road Heavy-Duty Diesel Engine Generator

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Abstract:

Emissions of non-road diesel engine is a potential (hidden) impact on atmospheric pollutants and local health effects. Multiple-component was developed for using the bio-producible or industrially recyclable hydrous solvent in this study. The Acetone-Butanol-Ethanol (ABE)-Diesel, developed by our group previously, were added with extra oxygenated diesel additives to further increase the engine performance and reduce the pollutant emissions. Glycerin (G) is the key oxygenated additive in this study since its multi-recyclable sources from industries and high density of oxygen content in a single compound. The ABE solution, glycerin, deionized water, and ultra-low-sulfur-diesel were emulsified to form thermodynamically stable fuel blends. There were four stable fuels found in this study, including ABE5G5, ABE15G5, ABE5HG5, and ABE15HG5. They showed stable probability density function (PDF) and volume density function (VDF) curve with small Sauter mean diameters (SMD). The SMD reduced with increasing ABE/G ratio, while ABE15G5 was found with the smallest SMD as 6.5 μm . A single cylinder heavy-duty diesel engine was then employed to test all fuel blends. The specific fuel rate increased with the increasing additive ratio, since their lower heating values. However, the specific thermal efficiencies of ABE-G diesels were even higher than the regular diesel, since the fuel oxygen indeed improve the combustion status. Meanwhile, the particulate matter (PM) and carbon monoxide (CO) were significantly reduced by adding ABE-G into diesel. Interestingly, the nitrogen oxide (NO_x) were reduced simultaneously, since the lower heating value and local cooling effect by the vaporization of water content to inhibit the thermal NO_x formation. Nevertheless, the emission factors of polycyclic aromatic hydrocarbons (PAHs) were also be reduced by 4, 15, 20, and 35% and 40, 55, 37, and 44%, at 1.3, and 2.6 kW engine operation load, respectively; meanwhile, the emission factors of BaP_{eq} were decrease 12, 28, 34, and 45%, and 44, 48, 51, and 60%. Consequently, this study finds a way for recycling the waste glycerin with not expensive pretreatment, it also develops a flexible content range of multi-

component micro-emulsified diesel for an engine generator to increase the thermal efficiency and reduce the pollutant emissions simultaneously.

Parallel Oral Session II

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

28 May 2019 (Tuesday) | 13:30 – 15:30

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Indoor air (1) Co-chair(s) 1. Norikazu Namiki, Kogakuin University 2. Ho Kin Fai, Chinese University of Hong Kong	Norikazu Namiki, Kogakuin University	Characterizing to form ultrafine particles from a fixing unit for laser printers and their suppression	13:30-13:45	Mr and Mrs Lau Tat Chuen Lecture Theatre (LT-5)
	Jean Jacques Godon, Laboratoire de Biotechnologie de l'Environnement	The anthropisation of indoor air: the example of Antarctic stations	13:45-14:00	
	Sau Chung Fu, The University of Hong Kong	Detachment of bacteria-laden droplet from dusty surface by centrifugal method	14:00-14:15	
	Ramakrishna Ramisetty, TSI Instruments India Pvt. Ltd.	On-line size segregated mass measurement of aerosols from traditional cookstove emissions in Central India using a Quartz Crystal Microbalance- Micro Orifice Uniform Deposition Impactor	14:15-14:30	
	Cynthia Isley, Macquarie University	DustSafe citizen science project	14:30-14:45	
	Scott Lowther, Lancaster University / Chinese Academy of Sciences	The performance of HEPA air purifiers in removing "real world" particles, a chamber study.	14:45-15:00	
	Jungsuk Lee, Hanyang University	Effect of a system air-conditioner on indoor air quality in a four-bed ward	15:00-15:15	
Bioaerosol (1) Co-chair(s) 1. Gedi Mainelis, Rutgers University 2. Patrick Lee, City University of Hong Kong	Gedi Mainelis, Rutgers University	Performance of Two Novel Bioaerosol Samplers in Laboratory and Field Trials	13:30-13:45	Chan Kei Biu Lecture Theatre (LT-6)
	Amin Piri, Yonsei University	Damage Prevention of airborne bacteria under continuous Electrostatic Air-to-Liquid Sampling	13:45-14:00	
	Qinghua Wang, National University of Defense Technology	Preparation and characterization of simulated toxin aerosol	14:00-14:15	
	Fangxia Shen, Beihang University	Pro-inflammatory effects of airborne particulate matters in relation to biological composition	14:15-14:30	
	Malgorzata Golofit-Szymczak, Central Institute for Labour Protection - National Research Institute	Influence of disinfection of the air-conditioning system on fungal contamination of vehicles	14:30-14:45	
	Patrick K. H. Lee, City University of Hong Kong	What molecular tools have taught us about the composition and transport of bioaerosols?	14:45-15:00	
Aerosol physics (1) Co-chair(s) 1. Daizhou Zhang, Prefectural University of Kumamoto 2. Atsushi Matsuki, Kanazawa University	Daizhou Zhang, Prefectural University of Kumamoto	Particles over the Yellow Sea collected onboard aircraft missions in 2009-2012	13:30-13:45	SAE Magnetics Lecture Theatre (LT-9)
	Atsushi Matsuki, Kanazawa University	Linkage between nighttime new particle formation and winter monsoon: Based on the long-term observation in Noto region, western coast of Japan	13:45-14:00	
	Li-Hao Young, China Medical University	Volatility and mixing state of ultrafine particles nearby an urban area in Taiwan	14:00-14:15	
	Rosaria Erika Pileci, Paul Scherrer Institut	Variability of physical and optical properties of freshly emitted and aged black carbon particles determined from stationary and mobile measurements in the Po Valley (Italy), during summertime	14:15-14:30	
	Cheng Wu, Jinan University	Characterization of light absorption amplification of black carbon aerosols in urban Guangzhou, China	14:30-14:45	
	Kwangyul Lee, Kanazawa University	Vertical distributions of particle number concentrations associated with new particle formation by aerial observation in Fukue Island, Japan	14:45-15:00	
	Haebum Lee, Gwangju Institute of Science and Technology	A study on new particle formation (NPF) events during 2016-2018 in the Arctic area (Ny-Alesund, Norway)	15:00-15:15	
Aerosol chemistry (2) Co-chair(s) 1. Qi Ying, Texas A&M University 2. Olli Sippula, University of Eastern Finland	Ru-Jin Huang, Chinese Academy of Sciences (KC Wong Foundation Invited Speaker)	Haze pollution: Chemical characteristics and secondary aerosol formation	13:30-14:00	Peter Ho Lecture Theatre (LT-10)
	Masao Gen, Chinese Research Academy of Environmental Sciences	Viscosity of erythritol and erythritol-water particles as a function of water activity: new results and an intercomparison of techniques for measuring the viscosity of particles	14:00-14:15	
	Yue Zhao, Shanghai Jiao Tong University	The role of NOx in the formation of secondary organic aerosol from ozonolysis of α -pinene	14:15-14:30	
	Olli Sippula, University of Eastern Finland	A high volume photochemical emission aging reactor (PEAR): Method characterization and comparison to a smog chamber	14:30-14:45	

	Qianyun Liu, Hong Kong University of Science and Technology	Primary and secondary emissions from a modern fleet of city buses	14:45-15:00	
	Qi Ying, Texas A&M University	Investigating the Atmospheric Age Distribution of Primary and Secondary PM during a Severe Wintertime Pollution Episode	15:00-15:15	
Aerosol exposure and health (1)	Di Hu, Hong Kong Baptist University	Integration analysis of high throughput biological and chemical data reveals the toxicity capacity of fine particulate matter (PM2.5) from various sources	13:30-13:45	Leung Ko Yuk Tak Lecture Theatre (LT-14)
Co-chair(s)	Yang Lan, National University of Singapore	Impacts of Ambient PM2.5 on Human Respiratory Epithelial Cells: Appropriate Choice of In Vitro Model	13:45-14:00	
1. Sebastian Oeder, Helmholtz Center Munich	Erwin W. Karg, Helmholtz Zentrum München	Particle deposition in a cell exposure facility: Is it comparable to the lungs?	14:00-14:15	
2. C. H. Jonathan Choi, The Chinese University of Hong Kong	Yu Ting Huang, National Yang Ming University	Study of Hazardous Air Pollutants in Fine Particles (PM2.5) and the resulting cardiovascular and pulmonary toxicities, Research in Taiwan	14:15-14:30	
	Xinghua Qiu, Peking University	Screening of Hydrophobic Organic Components of PM2.5 Associated with Cellular Response of Inflammation and Oxidative Stress	14:30-14:45	
	Sebastian Oeder, Helmholtz Center Munich	Standardisation of Air-liquid Interface Exposures of Human Lung Cells using a Model Diesel Aerosol	14:45-15:00	
	C. H. Jonathan Choi, Chinese University of Hong Kong	Addressing the nano-bio interactions of inhaled nanoparticles inside the lungs	15:00-15:15	

Characterizing to form ultrafine particles from a fixing unit for laser printers and their suppression

Norikazu Namiki

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Naoki Kagi, Tokyo Institute of Technology

Hoon Kim, National Institute of Public Health

Manabu Ohno, HP Japan Inc.

Abstract:

The emission of ultrafine particles (UFPs) less than 100 nm from laser printers or copiers has become an issue of great fear in indoor environments. ISO/IEC 28360 provides that the emission rate of UFPs (6 to 300 nm in size) from laser printers should be determined by measuring their number concentration using the specified test chamber. Further, the regulation of their emission from the printers was imposed to be less than 3.1×10^{11} particles per 10 min-printing by Blue Angel Standard. However, the countermeasures against their emission have been under taken insufficiently. Therefore, we employed a fuser unit which was a main source of UFPs from a laser printer, and performed experiments to grasp their generation mechanism and to suppress their formation. In addition, blank sheets or ISO-specified patterned sheets were fed to the fuser unit to determine the contribution of toner-derived UFPs to the total ones during the unit operation. As a result, it was found that there existed three main sources of UFP formation, that is, wax in toner, plasticizer in the fixing unit and siloxanes from silicone rubber for the pressure roller, and that the wax-derived particles dominated over 60% of the total volume of formed UFPs. Further, their number concentration was decreased by 45% using the ion feeding (IF) / electrostatic precipitator (ESP) method, and by 89% using the combination of the IF and the installation of filter unit with charged media.

The anthropisation of indoor air: the example of Antarctic stations

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Abstract:

Unprecedented in human history, nowadays people spend on average 90% of their time indoors and breathe this indoor air and the microbes associated with it. Indoor air is by definition outdoor air to which are added various components of anthropogenic origin, including a human component (faecal, respiratory, skin). However, the outdoor air is also impacted by various anthropogenic components, and thus the real impact of man is difficult to measure. Antarctic bases located in a pristine environment are an ideal model for understanding human contamination, since the outdoor air is free of microbes of anthropogenic origin.

The indoor air of five Antarctic stations located on Saint Georges island and belonging to five different countries (Uruguay, Chile, China, Argentina and Korea) was sampled and analyzed by 16S rDNA sequencing.

The results indicate that about half of the bacteria present have a human origin, which is higher than other indoor air samples analyzed. The other bacteria have essentially marine and/or psychrophilic origins. The microbial composition of all the samples is similar but not identical. The temporal dynamics (temporal variation) for the same station is comparable to the difference between stations (spatial variation). Thus, bacteria of human origin are easily identifiable from the air background and their presence in several samples will allow us to identify the bacterial species that typify an air environment polluted by humans.

Detachment of bacteria-laden droplet from dusty surface by centrifugal method

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HKU

W.T. LEUNG

S.C. FU, Hong Kong University

Christopher Y.H. CHAO, Hong Kong University

Abstract:

Coughing and sneezing can generate thousands of infectious disease droplets. The small droplets suspend in air for long time while the large droplets settle on desk or floor surfaces quickly. Some droplets may deposit in ventilation duct. These surfaces may not be clean but with dusts on it. Ventilation duct was dusty after long period of operation. The presence of the dust may affect the droplet detachment process and the survivability of the bacteria. The objective of this study is to investigate the detachment of pure droplet and bacteria-laden droplet from dusty surface.

Clean and dusty surface of stainless steel were used as substrate in the experiment. Clean surface was cleaned by water and alcohol to remove dust and oil. Dusty surface was prepared by suspending Arizona Test Dust in a chamber and then deposited on the substrate by gravity. The dust loadings on the substrate was 0.5g/m². Then the dust-loaded substrate was sterilized at 160°C for 2 hours. The droplet was a mixture of glycerol and water to simulate the nucleus of saliva. Micrometer-sized droplets with rod-shaped bacteria, *Escherichia coli* (*E.coli*), were generated using a vibrating orifice aerosol generator. The droplet was deposited on the substrate and the contact diameter of the droplet was captured by a microscope. Tryptone soya agar was poured at the cap of a substrate holder. Detached bacteria-laden droplet was deposited on the agar. The *E.coli* on the agar and the dusty substrate were cultured for 12 hours and the colony forming unit were compared.

After rotation in centrifuge, the pure droplet was partially detached. When the rotation speed was increased, the contact diameter of the remained portions became uniform independent of their initial contact diameter. The remained droplet was larger on dusty surface than on the clean surface. For the bacteria-laden droplet, the droplet was partially detached and *E.coli* can be found in both the detached portion and the remained portion. The partially detached bacteria-laden droplet can be a source of bioaerosol. The survivability of the bacteria after the detach process shall be studied.

On-line size segregated mass measurement of aerosols from traditional cookstove emissions in Central India using a Quartz Crystal Microbalance- Micro Orifice Uniform Deposition Impactor

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Keywords: QCM-MOUDI; OPS, SMPS, TSI Instruments; Fine-Ultrafine aerosol.

Abstract:

Indoor Air Pollution (IAP) due to the burning of solid fuels occurs in developing countries like India, mostly with greater concentration in rural households. Women and children spend the majority of their time indoors and are thus impacted the most. To plan for wide-scale action, like improvement in cooking stove technology, it is crucial to first assess what the current situation is, in different parts of the country. This study reports some results from a larger study aimed at characterizing aerosol emissions from indoor cooking using traditional stoves and its impact on ambient air quality.

Measurement of real-time number, mass and size distributions of nanometer-sized resolved aerosol particles with high time resolution has been a challenge till now. A recently introduced instrument from TSI – the Quartz Crystal Microbalance Micro-Orifice Uniform Deposit Impactor (QCM-MOUDI), has been developed to accomplish these requirements. Equipped with a six-staged cascade impactor, it provides real-time mass with 50 ng sensitivity in each stage. It has a novel relative humidity (RH) conditioner which ensures that aerosols are collected in the RH range 40% to 65% leading to high reductions in particle bounce.

We use several co-located instruments inside rural households during cooking periods including: 1) QCM-MOUDI for real-time size segregated mass distributions; post collection chemical analysis of samples, 2) Optical Particle Sizer (OPS) for real-time number based size distributions, 3) CO gas analyzer for measuring exfiltration rates, 4) Aethalometer to measure the concentration of optically absorbing species (BC). We report some preliminary results from these simultaneous measurements in

characterizing emissions from indoor cooking using traditional stoves with a focus on QCM measurements.

DustSafe citizen science project

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Abstract:

Background

Australian and international science and public health experts have collaborated to launch a new global citizen science program ('DustSafe') to examine environmental exposure from household dust. Currently, there is a lack of knowledge regarding indoor dust exposure even though people are spending increasing amounts of time indoors (up to ~90% of their day). Household dust particles may contain harmful agents that impact health via ingestion and inhalation pathways. However, the composition and risk associated with household dust is largely unknown. The program will address this knowledge gap by engaging with homeowners to collect and submit household vacuum dust samples and resident meta-data for geochemical and biological analysis.

Method and approach

Vacuum cleaner dust, collected by citizen scientists, will be analysed for metal(loid) concentration using X-ray fluorescence spectrometry (XRF) while mineralogy will be determined using X-ray diffraction. The program will operate independently in each partner country, with the Australian node having experts in capital cities who co-ordinate enquiries, public outreach and analysis. Global data will be uploaded to a web portal providing summary spatial, geochemical and mineralogical interpretation and guidance for participants.

The program's goal is to analyse a randomly sampled subset of samples for a wider range of organic and inorganic contaminants: asbestos, flame retardants, allergens, anti-microbial resistance genes, pesticides and dioxins, perfluorinated chemicals and lead isotopes for fingerprinting and sourcing. Samples for this comprehensive '360' high-resolution analysis will be stratified according to household age (20-year age bands covering properties from < 20 years old to >100 years old).

Results so far

Although just in its beginning stages, DustSafe has already received 378 household dust samples from all over Australia. Preliminary investigations have been focussed on metals. Based on the samples received so far Zn is the most abundant element with median of 1253 mg/kg (range 105 – 75367 mg/kg). Lead makes up about 7% of the analysed composition (median 125 mg/kg, range 7-9405 mg/kg). Cadmium

has not been detected in any samples so far. The remaining metals account for approximately 11% in the case of manganese; 11% copper; 4 % chromium, 2% nickel and 1% arsenic.

The median dust metal concentrations show that Cu, Mn, Pb and Zn are the most abundant in household dust. This is likely to be associated with paint and road dusts entering the home.

As community participation and sample numbers continue to increase, DustSafe will look next at asbestos, anti-microbial resistance markers, micro-plastics and flame retardants in household dust samples.

Conclusions

Dust is considered to be a key contaminant exposure source particularly for young children. The DustSafe program will provide insights into the prevalence of significant legacy and emerging contaminants and provide a unique platform for engaging the public about potential health risks from dust exposure in their homes.

The performance of HEPA air purifiers in removing "real world" particles, a chamber study.

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Lancaster University / Chinese Academy of Sciences

Kevin Jones, Lancaster University

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Abstract:

Indoor air pollution is a significant issue with people spending on average 90% of their time indoors. Particulate matter (PM) specifically can be a big issue, with indoor pollution sources being able to rapidly increase particle number concentrations by several orders of magnitude. In mega-cities where ambient PM can be extremely high or areas where there is poorer building quality and regulation; ambient PM can be the most important source of indoor PM. Indoor HEPA air purifiers provide one way to remediate this issue. However, not all HEPA air purifiers will perform equally, therefore the Association of Home Appliance Manufacturers (AHAM) provides a service to certify the performance of these air purifiers under controlled lab conditions. Nearly all named brand HEPA air purifiers will be rated by AHAM. The air purifiers receive a CADR (clean air delivery rate) which is the cubic feet per minute of particle free air being outputted by the air purifier. However, this standardized test only comments on the ability of these air purifiers to remove three types of particle compositions, namely; dust, pollen and tobacco smoke. It also does not comment on how effectively these air purifiers remove particles of different sizes, for example, how the removal rating might differ between 30-300nm. This investigation looks at how efficiently these air purifiers remove particles in the "real world", using outdoor ambient air in China to simulate the composition and properties of air in indoor environments. The efficiency of removing particles of different sizes between 17nm and 500nm was tested. For two out of the three air purifiers, the removal efficiency was similar to those of AHAM's test particle types, however, for one ambient PM was removed at a significantly lower rate than AHAM's test particles. For the most part, removal efficiency remains consistent over the 17-500nm size range, potentially disproving the hypothesis that particles at 30nm are the most difficult to remove. Further air purifiers should be tested to identify whether AHAM should consider using "real world" particles when testing their efficiency at removing PM.

Effect of a system air-conditioner on indoor air quality in a four-bed ward

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Hanyang University

Se-Jin Yook, Hanyang University

Abstract:

Particles smaller than 5 μm are classified as the particles capable of causing airborne infection. Efficient ventilation is important to prevent patients in a hospital ward from being infected by airborne viruses. In addition to the ventilation system, a system air-conditioner can be used to control the temperature in the ward and an air cleaner to remove airborne particles in the ward. In this study, we conducted a comparative analysis of the indoor air quality under the operation of a ventilation system, a system air-conditioner, and an air cleaner in the hospital ward. We also installed ward curtains, which are frequently used to protect patients' privacy. The age of air and the decay rate of particle concentration were used as indices to evaluate indoor air quality. The age of air was calculated by numerically simulating the airflow and particle concentration in the ward. The decay rate was experimentally obtained by measuring the concentration of the particles in the ward. The results of numerical analyses were verified by comparing with the experimental data. It was found that the local air quality in the 4-bed ward could be greatly influenced by the air flow pattern formed by the operation of the ventilation system, the system air-conditioner, and the air cleaner. It was found that the use of the ward curtains could also affect the local air quality in the 4-bed ward. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning, Grant number: 2017R1A2B2006927. ysjnuri@hanyang.ac.kr.

Performance of Two Novel Bioaerosol Samplers in Laboratory and Field Trials

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Abstract:

Investigations of the health and environmental effects of airborne biological agents require advance bioaerosol sampling techniques. Such techniques should provide reliable long-term sampling while preserving microorganism features that allow their identification and quantification through the use of various analysis techniques, including traditional culturing techniques as well as advanced sequencing approaches. Over the past years, significant strides have been made in bioaerosol sampling technology. We are contributing to this are by developing and testing several novel bioaerosol samplers. The first device is a self-contained, battery-operated, personal electrostatic bioaerosol sampler (PEBS) featuring high collection efficiency. In order to function as a personal sampler, the device was designed to operate for extended periods of time while emitting low ozone concentrations. The second device is a stationary electrostatics-based collector (SEBS) that concentrates air samples in small amounts of liquid to improve detection limit.

PEBS is a two-stage electrostatic precipitator consisting of a wire-to-wire charger and a dual half-cylinder collection chamber. Wire-to-wire charger produces very low ozone concentrations (only ~ 10ppb) compared to traditional wire-to-cylinder or wire-to-plate designs. The device operates at 10 L/min, and samples are collected on a removable stainless steel plate coated by a hydrophobic substance and then eluted into the liquid medium. SEBS operates at 20 L/min and collects microorganisms on a narrow (3.2 mm width), hydrophobic electrode, from which they are removed into a 20-40 micro liter droplet for analysis.

PEBS was tested in the laboratory when collecting *Bacillus atrophaeus* bacterial cells and *Penicillium chrysogenum* fungal spores at 10 L/min and for 10, 60, and 240 min. For 240 min sampling, its performance was compared against the BioSampler and the Button Aerosol Sampler (both SKC Inc., Eighty Four, PA) when sampling bioaerosols outdoors. SEBS device was tested in the laboratory and then in various indoor and outdoor environments against Button Aerosol Sampler (SKC Inc.) when operated for 4-8 hours.

The collection efficiency of PEBS was approximately 80% when sampling *B. atrophaeus* bacteria and *P. chrysogenum* fungal spores. In field experiments, cell viability and culturability of PEBS were expressed as Relative Luminescence Units [adenosine triphosphate (ATP) method], a ratio of Live/Dead cells (flow

cytometry), and Colony Forming Units (culture technique), and compared against that of the two reference samplers. The fractions of Live, Injured, Dead and Unstained cells of PEBS were 65%, 10%, 12%, and 13%, respectively and not different from those of BioSampler and Button Sampler. The fractions of culturable cells were also not statistically different ($p>0.05$). SEBS exhibited collection efficiency of 50-60% when sampling *B. atrophaeus* bacteria. Due to liquid volume of 20 μ l and flow rate of 20 L/min, it exhibited a superior sample concentration rate, e.g., $\sim 6 \times 10^5$, allowing users to detect low microorganism concentrations.

The two devices are showing great promise as personal and stationary bioaerosol sampling tools, and it is hoped that after additional testing and validation they will be adopted by the bioaerosol research community.

This work is supported by CDC/NIOSH grants R2110560 and 2R0109783.

Damage Prevention of airborne bacteria under continuous Electrostatic Air-to-Liquid Sampling

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Abstract:

Human exposure to airborne pathogens is the major cause of health concerns, hence, it is imperative to monitor, sample and detect airborne bio-particles. Among various bio-aerosol sampling methods, electrostatic precipitation (EP) is an efficient technique to capture bio-aerosols owing to lower pressure drop and less damage to sensitive bio-particles. During sampling process, intensity and polarity of applied voltage, current, type of liquid used for sampling and the liquid flow rates can have high impacts on the efficiency of sampling. Particularly, corona discharge can ionize the surrounding air, leading to production of reactive oxygen species (ROS) which can be dissolved and transported into the liquid causing destructive effects to DNA and induce structural modifications of cell components. Thus, since for bio-aerosols detection DNA must be undamaged, it is vital to find the optimal sampling conditions that show the least damage to the bio-aerosols. Nonetheless, for the first time we apply ascorbic acid as the sampling solution when using aerosol-to-hydrosol electrostatic air sampler to identify the optimal chemical and physical sampling condition that can have the minimum damage to the bio-aerosols.

Preparation and characterization of simulated toxin aerosol

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Abstract:

Toxins are toxins produced by organisms. These substances are usually proteins that interfere with the action of other macromolecules in organisms and are high-risk biological macromolecules. Toxins can be released through aerosols, threatening large-scale personnel and equipment. Real-time monitoring of toxin aerosols is very important. In this study, toxin mimics were screened; a set of preparation technology of simulated molecular toxin aerosol was developed and characterized.

Since most of the known toxins are protein toxins, laboratory research needs special post-processing technology, which has great potential safety problems. The amino acid and protein are chosen as the mimic molecules of toxin considering the similarity of molecular structure and toxin molecule. Focusing on aerosol preparation and fluorescence detection, the solubility, stability and fluorescence spectrum characteristics of simulated molecules were studied. The feasibility of simulated toxins was also studied. The experiment selected the L-tryptophan and bovine serum albumin two toxins simulation. L-tryptophan's fluorescence spectrum optimum excitation wavelength was 252 nm, best detect linear concentration range was 1.0×10^{-5} - 1.0×10^{-3} mol•L⁻¹, measured the fluorescence spectrum and the standard curve in this concentration range. Bovine serum albumin's fluorescence spectrum optimum excitation wavelength is 280 nm, measured the fluorescence spectrum and the standard curve in 1.0×10^{-6} - 1.0×10^{-4} mol•L⁻¹ concentration range of bovine serum albumin. Under the 206 nm excitation light fluorescence quenching effect was significant, so it was inconvenient to measure the fluorescence spectrum under this excitation wavelength.

In this study, the aerosol was prepared by liquid phase dispersion method, a simple aerosol generator and operation box was designed, and characterization methods such as plane sampling, microscopic photographs were established, which realized the aim of aerosol preparation and characterization of stability, particle size. Solution prepared out of 0.01 mol•L⁻¹ L-tryptophan dilute hydrochloric acid, using

the self-designed aerosol preparation device could stay stable at least 1 hour in the option box. There were three typical particle size particles in aerosol, 3-5 μm 、 10-15 μm and larger than 50 microns 50 μm .

Pro-inflammatory effects of airborne particulate matters in relation to biological composition

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Abstract:

China has experienced frequently serious haze weather in recent years. Strong association between haze events and respiratory as well as cardiovascular disease was reported. Although fine particulate matter (PM_{2.5}) was shown to play a crucial role in the higher incidence and exacerbation of respiratory diseases, the key underlying mechanisms are still not well understood. In our study, PM_{2.5} samples were collected during a haze period in winter 2016 of Beijing, China. Characterization of the PM_{2.5} samples were performed, including ions, metals, redox activity and particle-bound LPS. We measured inflammatory cytokine releases from human macrophages that were exposed to the water elution of PM_{2.5} from distinct days. Additionally we mixed (spiked) these PM_{2.5} extracts with lipopolysaccharide (LPS), to mimic the high levels of LPS, which might happen in the polluted days or in sick individual with an inflammatory respiratory tract with a high bacterial load. Differential cellular inflammatory signals, i.e., interleukin 8 (IL-8), IL-1 β and tumor necrosis factor (TNF), were observed upon exposure to the PM_{2.5} from same volume of air but from distinct days at sub-toxic levels. Compared to the macrophages treated with PM_{2.5} alone, up to 13-folds more IL-8 were released from macrophages treated with PM_{2.5} spiked with LPS (100 pg/mL). Moreover, changes in the expression of oxidative stress-related genes were observed to depend on PM_{2.5} mass levels. When spiked with LPS at 100 pg/mL, 2.5-folds

higher up-regulation of the gene superoxide dismutase 2 (SOD2) was observed for the sample collected from polluted day compared to that from clean day. Our results suggest that LPS along with other constituents mediates the PM2.5-related inflammatory effects, thereby might contribute to the deterioration of existing chronic respiratory disease, like chronic obstructive pulmonary disease (COPD). This work highlights the need to consider the biological fraction of PM2.5 such as LPS when assessing its health effects.

Influence of disinfection of the air-conditioning system on fungal contamination of vehicles

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Abstract:

The automotive air conditioning (AC) installations are usually a good environment for the development of fungi.

The aim of this study was to evaluate the level of fungal contamination before and after servicing the automobile AC system, based on qualitative and quantitative analyses of microorganisms isolated from the air.

This study was carried out in 30 passenger cars, 6 buses and 8 trucks. Four methods were used to disinfect AC installation in the examined passenger cars: ozonization, application of chemical disinfectant using ultrasounds, manual application of chemical disinfectant in a foam form and complex method (ozonization combined with application of chemical disinfectant substance in a foam form). In trucks the manual method of spraying the chemical preparation was the only one used, while in buses ozonization or manual application of chemical disinfectant in spray form were being used.

Air samples were collected before and after disinfection of AC systems in studied cars. In each studied car, bioaerosol samples were collected using single-stage MAS impactor. The flow rates as well as sampling times were 100 L/min and 1.5 min, respectively. During the tests, impactor was placed within the zone of about 0.5m from vent/supply air outlets located next to the steering wheel and at the height of 1m above the car's floor level and to simulate aspiration from the human breathing zone of the car driver/passenger. Fungal aerosol concentrations were estimated and isolated microorganisms were taxonomically identified upon their morphological, biochemical and molecular features.

The fungal concentrations in car air samples before AC servicing were between 2.2×10^2 cfu/m³ in passenger cars and trucks, and 2.4×10^2 cfu/m³ in buses. After conducting the AC service using all four methods, the decrease in microbial concentrations was observed.

The highest cleaning efficiency was observed after distribution of the chemical disinfectant in the interior of the passenger cars using the ultrasound (76.6% on average) while in trucks and buses (manual method of spraying the disinfectant), 53.4% and 67% on average, respectively.

The most prevalent fungal species in the air in all studied vehicles were those from *Alternaria*, *Aspergillus*, *Cladosporium* and *Penicillium* genera. Among isolated microorganisms, human pathogens from *Aspergillus* and *Epidermophyton* genera were identified.

The tested methods of disinfection of AC systems in the studied cars were so efficient that the reduction of fungal contamination of the air inside the vehicles was obtained. The fact that pathogenic fungi occur in car AC systems shows that the disinfection of automobile AC system must be done at regular basis.

What molecular tools have taught us about the composition and transport of bioaerosols?

Patrick K. H. Lee

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Abstract:

Biological matters including bacteria, fungi, viruses and pollen are part of bioaerosols in indoor and outdoor environments. Unlike the chemical counterpart, we have fewer tools, especially real-time instrumentation, available to measure the composition of biological matters. Traditional methods such as culturing are time-consuming and most likely underestimating the true composition of bioaerosols. However, with advanced culture-independent molecular methods, we can now gain better insights into the composition of bioaerosols and the metabolic status of the organisms, which has implications for the reactions that occur in the atmospheric environments. Using Hong Kong as a model system, we have applied high-throughput molecular methods to characterize the composition, spatial and temporal distribution, and transport of bioaerosols in indoor and outdoor environments. We have also developed a method to determine whether the organisms present in air are dead or alive, which surprisingly, a high diversity of organisms are in fact alive. In addition, we have compared the bioaerosol composition of six cities located in Asia, Europe and North America. Interestingly, we have found that geography is a factor that strongly influences the composition of bioaerosols. In the future, together with other advanced tools such as real-time optical techniques, our understanding of the composition, concentration and transformation of bioaerosols will continue to enhance and this will in turn enable us to gain a clearer picture of the indoor and outdoor atmospheric environments.

Particles over the Yellow Sea collected onboard aircraft missions in 2009-2012

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Shiro Hatakeyama, Center for Environmental Sciences in Saitama, Japan

Abstract:

In this study, aerosol particles were collected at different altitudes in three aircraft missions over the Yellow Sea when the influence from Asian continental outflows was expected. The particles were identified by their shape and elemental composition. According to the thermodynamic structure, the layer from the surface to about 1000 m was the convective mixing layer (CML) and above 3000 m was the low free troposphere above 2000 m (LFT). Between the two layers was an entrainment zone (EZ).

Soot particles were predominant at all altitudes, besides ammonium sulfate particles. The particles were coated with a layer of weak electron absorption materials, indicating the aged status of the particles. In the EZ, almost all particles were present as an inclusion of a droplet-like particle. The coating was clear and substantial, indicating the particles were wet aerosols. In contrast, a large fraction of LFT particles in the satellite structure indicate their contents of acidic materials likely sulfuric acid or ammonium hydrogen sulfate. Sulfur was identified in the aqueous layer of the particles indicating the coating materials contained secondary sulfur compounds, most likely sulfate. The presence of sulfuric-coated soot particles in the LFT suggests that sulfuric acid could be efficiently produced on the surface of soot particles even in less anthropogenically-polluted air, i.e. such particles were not secondary particles but primary particles coated with secondary species of H_2SO_4 and NH_4HSO_4 . Therefore, anthropogenic soot particles had likely played a key role in the mass conversion from the convective mixing layer to the lower free troposphere in the Asian continent outflow. They enhanced the formation of secondary species by providing reaction site, absorbed volatile species and, consequently, could have impact the solar radiation transfer and distribution and cloud droplet formation but in different manners in different layers.

Linkage between nighttime new particle formation and winter monsoon: Based on the long-term observation in Noto region, western coast of Japan

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Kanazawa University

Hiroyuki Hyono, Kanazawa University

Kento Kinouchi, Kanazawa University

Masaki Furuya, Kanazawa University

Hiroshi Tsurumaru, Tokyo Metropolitan Research Institute for Environmental Protection

Yoko Iwamoto, Hiroshima University

Abstract:

The new particle formation (NPF) is an important initial process for the aerosols to nucleate and eventually act as Cloud Condensation Nuclei (CCN). It is therefore important in understanding the contributions of aerosols on the climate and air quality. During the last couple of decades, NPF events have been observed in many different environmental settings in the world. Most of the studies agree that NPF is largely a daytime phenomenon. However, some studies have also reported nighttime NPF in the absence of solar radiation, but the mechanism of nighttime NPF is not as well understood due partly to the lack of long-term observation.

We have been measuring particle size distribution at the tip of Noto Peninsula on the western coast of Japan since October 2012. Particles in the size range 8-360nm have been measured by a SMPS (Scanning Mobility Partciel Sizer, TSI Inc.) at NOTOGRO (37.45°N, 137.36°E, acronym for NOTO Ground-based Research Observatory) located in Suzu City.

A distinct seasonality emerged through our long-term observation, and the NPF frequency were particularly high in spring (May) and in late autumn (November). In spring, NPF events were concentrated during the daytime and cloud cover frequency was particularly low when the events occurred. Like most of NPF reported elsewhere, events were most strongly driven by solar radiation (hence photochemistry). On the other hand, nighttime NPF events were most frequently observed in late autumn. The study area is subject to strong winter monsoon and predominant north westerly wind frequently bring rain and/or snow. It is reported that radon progeny (Pb-214, Bi-214) in the continental air-mass is rained out and cause temporal rise in the ambient gamma ray dose rate especially along the western coast of Japan (Inomata et al., 2007; Tanaka et al., 2016). Indeed, preceding precipitation can be found around the time of nighttime NPF onset, and associated rise in the ambient gamma ray dose rate was also observed by the JAEA (Japan Atomic Energy Agency) monitoring network. The seasonal

maximum of the ambient dose rate also occurred in November to December. Based on these observations, temporal rise in the ambient gamma ray dose rate and associated ion production was proposed as the feasible triggering mechanism (i.e. ion-induced nucleation) of the nighttime NPF observed in the study area.

Volatility and mixing state of ultrafine particles nearby an urban area in Taiwan

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Abstract:

Ultrafine particles (UFPs, <100 nm) are ubiquitous in the ambient air and have important implications in climate, environmental and human health. Volatile materials contribute a significant mass fraction of UFPs, and the associated mixing state affects UFPs optical properties and CCN activity. The objective of this study is to characterize the temporal- and size-dependency of the volatility and mixing state of size-selected UFPs. Measurements were taken with a volatility-tandem differential mobility analyzer (V-TDMA) nearby Taichung urban area in Taiwan over a year. Particles of three mobility sizes of 35, 55 and 100 nm were thermo-conditioned under three temperatures of 25, 125 and 300°C. Accordingly, the measured volatile materials were classified into three categories, non-volatile (NV), low-volatile (LV) and high-volatile (HV). The results indicate that the mixing state of UFPs under 125°C showed rather complex seasonal and size dependencies. On the other hand, the mixing state under 300°C showed little seasonality but clear size-dependency, with increased external mixing with increasing particle size up to 100 nm. Particles of varying sizes showed distinctly different volatility, though no seasonal dependence was observed for a given particle size. The highest contributor to the 35-nm particles was NV materials, the 55-nm particles was HV materials, and the 100-nm particles was LV materials. Overall, the results suggest that the mixing state of UFPs depends on heating temperature, particle size and season, whereas the volatility of UFPs depends largely on particle size. These complex relationships in turn are indicative of the varying sources and aging processes of UFPs.

Variability of physical and optical properties of freshly emitted and aged black carbon particles determined from stationary and mobile measurements in the Po Valley (Italy), during summertime

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Abstract:

Black carbon (BC) particles are the main light-absorbing component of atmospheric aerosols. They affect the climate system globally and regionally and are damaging to human health. The characterization of the spatio-temporal variability of the physical and optical properties of black carbon particles is of great importance in evaluating their climate and health effects; particularly in the Po Valley, Italy, which is one of the most polluted regions in Europe and home to almost 20 million inhabitants. For example, a deeper knowledge of the variability in BC mass absorption cross-section (MACBC) in relation to BC properties such as core size and mixing state is required to elucidate the main factors that drive changes in light absorption due to BC, and BC radiative effects more generally.

To characterize the spatio-temporal variability of important BC-related properties in the Po Valley we performed field measurements in July 2017 with a mobile measurements van. The van was equipped with a large payload of instruments including a Single Particle Soot Photometer (SP2), a High Resolution Aerosol Mass Spectrometer (HR-AMS) and various absorption photometers (MAAP, AE33) for measuring properties such as absorption coefficient, rBC mass concentration, Absorption Angström Exponent (AAE) and MACBC. Both mobile and stationary measurements were performed with the van over the Valley. The stationary measurements were performed at: Consiglio Nazionale Ricerche (CNR; sub-urban site in Bologna), San Pietro Capofiume (rural background site) and Monte Cimone (remote high-altitude site).

AAEs (470 – 950 nm) values all over the Valley ranged between 0.8 and 1.2, indicating the main BC source contribution was traffic emissions. The stationary measurements at the CNR site indicated that the diurnal cycles in BC properties were dominated by the interplay of local sources and planetary boundary layer (PBL) dynamics. For instance MACBC @ 637 nm varied over the range 11.8 - 18.7 m² g⁻¹ (absolute values would be lower if calculated with respect to thermal-optical EC mass): the minima occurred in the morning when fresh traffic emissions dominated the aerosol loading and the maxima occurred in the afternoon when PBL height increased and BC mass was dominated by aged particles. Spatial variability was investigated by driving over the Valley along two different types of streets (highway and rural road) 10 km distant from each other. MAC_{BC} increased from an average of 16.6 µg/m³ on the highway to 22.2 µg/m³ on the rural road. Both the stationary and mobile measurements showed that higher fraction of BC from fresh traffic emissions was related to higher fraction of externally mixed BC. These results support the hypothesis that during summer in the Po Valley freshly emitted BC particles are very quickly diluted in a pool of aged internally-mixed BC particles.

A clear positive relationship was found between the number fraction of thickly coated BC particles and MACBC, while the variation in BC core size was too small to explain the overall variations in MACBC. Therefore, variations in BC mixing state was the main factor driving MACBC variations, indicating that atmospheric aging increases the MACBC via “lensing-effect”.

Characterization of light absorption amplification of black carbon aerosols in urban Guangzhou, China

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Abstract:

Black carbon (BC) aerosols is an important climate forcer in the atmosphere. Light absorption amplification remains one of the major sources of uncertainties for accessing the radiative forcing of BC. In this study, the absorption enhancement factor (Eabs) was quantified by the minimum R squared (MRS) method using elemental carbon (EC) as the tracer. The field campaign was conducted in urban Guangzhou at the Jinan University Super site (JNU) during both wet season (July 31-September 10, 2017) and dry season (November 15, 2017 - January 15, 2018). The average concentration of EC was 1.90 ± 0.94 and $2.80 \pm 2.01 \mu\text{gC m}^{-3}$ in the wet and dry season, respectively. Eabs520 in urban Guangzhou was higher in the wet season (1.52 ± 0.52) and lower in the dry season (1.28 ± 0.28). In addition, OC, EC, OC/EC, and absorption Ångström exponent (AAE470-660) in the dry season were higher than the wet season. The diurnal variations of Eabs520 in the wet and dry season exhibit different patterns. Further analysis showed that the daily variation of Eabs520 was positively correlated with AAE470-660 ($R^2=0.71$) and negatively correlated with the aerosol loading compensation parameter (k) ($R^2=0.74$) in the wet season, but these correlations were significantly weaker in the dry season, which may be related to the impact of biomass burning. The influence of oxidant concentrations ($\text{OX}=\text{O}_3+\text{NO}_2$) on Eabs520 was observed. OX and Eabs520 were well correlated in the dry season ($R^2=0.69$) and no correlation was found in the wet season.

Vertical distributions of particle number concentrations associated with new particle formation by aerial observation in Fukue Island, Japan

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Abstract:

Atmospheric aerosol formation is an important effect on aerosol particle number concentrations and climate through indirect radiative effects. Our previous researches indicated that new particle formation (NPF) in the Northeast Asian region is strongly influenced by the photochemical processes during long-range transport of air pollutants (Seto et al., 2013, Chandra et al., 2016).

In this study, vertical distributions of atmospheric particles number concentrations (measured by CPC; Size > 6 nm; altitude of < 1.2 km) were investigated by using the Kite Plane (Sky Remote Co. Ltd.) from April 13 to April 20, 2018 at Fukue Island, Japan. The boundary layer and free troposphere was determined by the vertical distributions of temperature and relative humidity.

In this presentation, we focus on the vertical distribution of atmospheric particle number concentrations observed on April 20 and April 21, 2018. In these days, we observed four vertical profiles of particle number concentrations at an altitude below 1200 m. On April 20, the layer with higher particles number concentrations were identified in the free troposphere. During 1st flight, atmospheric particles number concentrations were slightly increased above 1000 m altitude. After 2nd flight, the layer with high particle number concentrations appear and these gradually downward transported from 900 m to 500 m. In these flights, maximum number concentrations were slightly increased from 4,800 to 5200 particles per cubic centimeter.

On April 21, downward transport of higher particles number concentrations layer was observed from 1st to 3rd flight. The particle number concentrations at 2nd flight, which account to 35,600 particles per cubic centimeter, was about two times larger than those during 1st flight (15,500 particles per cubic centimeter), suggesting the NPF occurred. During 3rd and 4th flights, the high particle number

concentration layer gradually transported downward in the boundary layer. It is also found that air mass is changed from the westerly continental to oceanic one. These results suggest that NPF event occurs in the free troposphere in the upstream region under the continental influenced air mass at Fukue islands.

(Reference)

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Chandra et al. (2016). New Particle Formation under the Influence of the Long-Range Transport of Air Pollutants in East Asia. *Atmos. Environ.* 141: 30-40.

A study on new particle formation (NPF) events during 2016-2018 in the Arctic area (Ny-Alesund, Norway)

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Abstract:

New particles formed in the ambient atmosphere can grow into sizes of which act as cloud condensation nuclei (CCN) affecting cloud formation (Seinfeld and Pandis, 2006). New particle formation (NPF) events were observed in all over the World regardless of site types (urban, rural, background sites and so on) including the Arctic area (C.-H. Jeong et al., 2010; I Chandra et al., 2016). The Arctic haze was observed in spring with increased pollutants transported from continents (Rahn and Shaw, 1977). Also, NPF events in the Arctic were often observed in summer (J Heintzenberg, et al., 2017). In this study, number size distribution of nanoparticles in the size range of 3 nm to 60 nm has been continuously measured since 2016 at the Zeppelin laboratory (78.91° N, 11.88° E) in Ny-Alesund, Norway by using a scanning mobility particle sizer (SMPS) which includes a nano-differential mobility analyzer (nano-DMA) (3081, TSI, USA) and an ultrafine condensation particle counter (UCPC) (3776, TSI, USA). Averages of particle number concentrations (particles/cm³) in the size ranges of 3-60 nm, 3-20 nm, and 20-60 nm during the measurement period (10/1/2016-10/31/2018) were 155 (± 403), 83 (± 291), and 71 (± 177), respectively. The highest monthly number concentration was observed during June and July every year. The number concentration of nanoparticles increased typically at between 12:00 and 16:00 in a day. NPF events were often observed from late April to early September (spring to summer). Average growth rates (GR) in 2017 and 2018 were 0.91 nm/h and 1.01 nm/h, respectively. Statistical criteria were developed to identify and predict the NPF event.

Haze pollution: Chemical characteristics and secondary aerosol formation

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Abstract:

Haze extremes in China are characterized by exceedingly high fine particle concentrations and occur with extensive temporal and spatial coverages. Understanding of the chemical composition and sources of fine particles, the mechanisms and atmospheric processes of substantial wintertime secondary aerosol production, and the constraint of sources and formation processes of secondary organic aerosol during haze pollution events are essential for improved understanding of the haze events. Here, we provide a synthetic overview of our recent results from field and laboratory studies. In particular, we highlight the chemical characteristics, formation and transformation of secondary aerosol during haze events.

Viscosity of erythritol and erythritol–water particles as a function of water activity: new results and an intercomparison of techniques for measuring the viscosity of particles

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Abstract:

Tetrols are formed via the atmospheric oxidation of isoprene followed by the hydrolysis of isoprene oxidation products. A previous study reported an uncertainty of up to 3 orders of magnitude for the viscosity of erythritol (1,2,3,4-butanetetrol)–water particles. To help reduce the uncertainty in the viscosity of these particles, we measured the diffusion coefficient of a large organic dye (rhodamine B isothiocyanate–dextran, average molecular weight $\sim 70,000$ g/mol in an erythritol–water matrix as a function of water activity using rectangular-area fluorescence recovery after photobleaching (rFRAP). The diffusion coefficients of rhodamine B isothiocyanate–dextran were then converted to viscosities of erythritol–water particles using the Stokes–Einstein equation. In addition, we carried out new viscosity measurements of erythritol–water particles using aerosol optical tweezers. Based on the new experimental results and viscosities reported in the literature, we conclude the following: (1) the viscosity of pure erythritol is $184 (+122) (-73)$ Pa s (mean \pm 2 standard deviations); (2) the addition of a hydroxyl (OH) functional group to a linear C4 carbon backbone increases the viscosity on average by a factor of $27 (+6) (-5)$ (mean \pm 2 standard deviations); and (3) the increase in viscosity from the addition of one OH functional group to a linear C4 carbon backbone is not a strong function of the number of OH functional groups already present in the molecule up to the addition of three OH functional groups, but the increase in viscosity appears larger when the linear C4 carbon backbone already contains three OH functional groups. These experimental results should help improve the understanding of the viscosity of secondary organic aerosol particles in the atmosphere. In addition, these results show that at water activity > 0.4 the rFRAP technique, aerosol optical tweezers technique, and bead-mobility technique give results in reasonable agreement if the uncertainties in the measurements are considered. At water

activity < 0.4 , the mean viscosity values determined by the optical tweezers technique were higher than those determined by the bead-mobility and rFRAP techniques by 1–2 orders of magnitude. Nevertheless, the disagreement in viscosity measured using multiple techniques reported from this work is smaller than reported previously.

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The role of NO_x in the formation of secondary organic aerosol from ozonolysis of α -pinene

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Abstract:

Atmospheric oxidation of monoterpenes is an important, and sometimes dominant, source of secondary organic aerosol (SOA) in the regions impacted by forest emissions. Organic peroxy radicals (RO₂) are key intermediates in monoterpene oxidation and their fates determine the product distribution and SOA formation. As ubiquitous and important trace gases in the atmosphere, NO_x are expected to be crucial in controlling the fate of RO₂ radicals. However, the role of NO_x in monoterpene-derived RO₂ chemistry, especially for RO₂ species from ozonolysis, is still poorly constrained, and the relevance of certain favorable SOA formation pathways such as RO₂ autoxidation and cross-reactions (forming gaseous ROOR' dimers) in polluted atmosphere remains to be evaluated. In this work, we present a detailed experimental investigation of ozonolysis of α -pinene in the presence of NO and/or NO₂ using a flow reactor (30-120 s reaction times), with an emphasis on NO_x effects on product distribution and SOA formation. The initial concentrations of α -pinene, O₃, and NO_x were carefully selected to avoid significant NO₃ oxidation chemistry in the flow reactor. The molecular composition of gaseous products and SOA particles were characterized using two high resolution mass spectrometry (HR-ToF-CIMS and HPLC-ESI-QToF-MS). The influences of water vapor, OH, and SCI scavengers on NO_x effects on SOA formation were explicitly examined. Implications for monoterpene SOA formation under typical atmospheric conditions are discussed.

A high volume photochemical emission aging reactor (PEAR): Method characterization and comparison to a smog chamber

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Abstract:

One of the main challenges for the assessment of the environmental effects of combustion emissions is their continuous transformation during atmospheric transport. Photochemical aging may change the toxicological, chemical, and physical properties of the emissions. The devices used to simulate aerosol photo-oxidation include smog chambers and different flow tube reactors. The modern air-liquid cell exposure devices used in toxicological studies, with combined physico-chemical characterizations of aerosol emissions, require relatively high amounts of aerosol sample. To provide sufficient sample flow rates of aged aerosols for these studies, a High-Volume Photochemical Emission Aging Reactor (PEAR), capable of photo-oxidizing high emission volumes and concentrations, was designed and constructed. In this work, the PEAR method was characterized by performing CFD-simulations and various experiments using single secondary organic aerosol (SOA) precursors and various combustion emissions. Finally, a comprehensive comparison of the aging in the PEAR vs. a 29 m³ smog chamber, equipped with black lights, was conducted using logwood stove as an emission source (Tiitta et al., 2016).

The PEAR is constructed from stainless steel tube which has 254 nm UV lamps assembled at the inner walls. Ozone and water vapor are added into the reactor to produce OH radicals via photolytic decomposition of O₃. The inlet of the reactor consists of a flow diffuser, which is designed to achieve a near laminar flow profile in the reactor when used with the designed flow rates (50-200 lpm). Computational fluid dynamics were applied in designing the reactor geometry and, furthermore, to estimate the UV light exposure and the paths of the particles inside the PEAR.

Aging processes of the logwood stove emission aerosols in the PEAR and the smog chamber were measured using SP-AMS (Aerodyne), PTR-ToF (Ionicon), SMPS (TSI) and trace level gas analyzers (O₃, NO, NO₂, SO₂, CO₂). Filter samples were collected from both aging systems for comprehensive offline chemical analysis. Organic aging products were studied using (-)-ESI FT-ICR MS (7T, Bruker Daltonics) for molecular level analysis of the water soluble fraction of organic carbon (WSOC), while untargeted direct thermal desorption of the filters by GC-GC-ToF MS (Leco) was used to provide deep insight to the whole organic aerosol composition.

Photochemical aging in both PEAR and smog chamber approximately doubled the organic aerosol (OA) concentration of the wood burning emissions. The AMS mass spectra and calculated oxidation state of OA was similar in PEAR and the smog chamber at similar OH exposures. Furthermore, an intermediate slope of Van Krevelen diagram indicated similar oxidation reactions (e.g. fragmentation and functionalization) in PEAR and in the smog chamber. Oxidation states were similar to ambient air levels, between -0.6 and -0.7. FT-ICR MS analysis indicated that photochemical aging increased oxidation state and nitrogen-containing compounds in the WSOC, while the double bond equivalent decreased.

Acknowledgements:

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Primary and secondary emissions from a modern fleet of city buses

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Abstract:

Exhaust emissions of 234 individual city buses were measured under real-world stop-and-go traffic conditions at a bus stop in Gothenburg, Sweden. The buses comprised models fulfilling Euro III-VI and EEV (Enhanced Environmentally Friendly Vehicle) standards with different fuels. The potential effect of changing to a non-fossil fuel vehicle fleet was investigated by measuring primary emission factors (EF) and secondary gas and particle formation downstream a Gothenburg Potential Aerosol Mass (Go:PAM) reactor. Regarding the particle phase, replacing diesel by biodiesel and biogas fuel reduced the fresh EF of particle mass (PM) significantly (by a factor of 2.7 and 5, respectively). However, secondary particle formation resulting from exhaust aging was generally significant for all the fuel types tested, suggesting an essential nonfuel dependent source. Regarding the gas phase, EFs of glycolic acid, glyoxylic acid, dihydroxy acetic acid, lactic acid, pyruvic acid, and malonic acid varied from 0.8-6.3 mg kg⁻¹ fuel and were well correlated with EF of HNO₃ ($r^2 = 0.65-0.97$) from the aged emissions. The results suggest that the potential for forming secondary mass should be considered in future fuel shifts since the environmental impact is different when only considering the primary emissions. The results also highlighted the importance of including both primary and secondary anthropogenic sources in budgets of low molecular weight organic acids. The inclusion of secondary pollutant sources in emissions regulation may lead to a more accurate portrayal of the potential impact of mobile sources or emissions control procedures on regional air quality.

Investigating the Atmospheric Age Distribution of Primary and Secondary PM during a Severe Wintertime Pollution Episode

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Abstract:

High PM_{2.5} concentrations are still frequently observed in many areas in China, particularly in winter. The occurrence of these events has been shown to be highly controlled by meteorological conditions with polluted and clean days often occurring periodically. One of the unresolved questions regarding the formation of PM_{2.5} during these high pollution events is how fresh and aged emissions interact and their respective contributions to the rapid increase of primary and secondary PM. A better understanding of how freshly emitted and aged PM_{2.5} and their precursors contribute to total PM_{2.5} concentrations will allow policymakers to design cost-effective urgent emission control measures when adverse meteorological conditions are predicted.

In this study, the Community Multiscale Air Quality (CMAQ) model with a unified source- and age-resolved gases and particle representation framework is applied to investigate the January 2013 severe PM_{2.5} pollution episode in China. In the age-resolved model, the same pollutant emitted at different times (thus with different atmospheric ages) are tracked independently through the model simulations of emission, transport, transformation and removal processes so that the age distribution of the pollutant can be directly determined. To determine the age-distribution of secondary PM_{2.5} components, such as ammonium nitrate, their gas phase precursors are also modeled as age-resolved mixtures using a modified gas phase chemical mechanism. We expect to present, based on the modeling results, the hour-by-hour evolution of the age-distribution of elemental carbon (EC), organic carbon (OC), nitrate (NO₃⁻), sulfate (SO₄²⁻) and ammonium ion (NH₄⁺) and the precursor gases at major urban areas as well as in regional scale during the one-month high pollution period. The correlation of atmospheric age with meteorological parameters will be study to better understand how meteorological conditions affect the accumulation and retaining of pollutants.

Integration analysis of high throughput biological and chemical data reveals the toxicity capacity of fine particulate matter (PM2.5) from various sources

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Abstract:

Ambient fine particulate matter (PM2.5) is the 5th leading global mortality risk factor. Current mass-based PM2.5 control measures may not be effective enough to protect human health, since the adverse health outcomes from PM2.5 pollution are not just related to the abundance of PM2.5, but also its chemical composition and sources. Here we used zebrafish embryo (AB strain) as a model to assess PM2.5 toxicity through genome-wide gene transcriptional analysis. We identified differential expression genes (DEGs) between PM2.5 extract treated and untreated zebrafish embryo samples, and found that they were mainly associated with responses to xenobiotic stimulus, and muscle and heart development and functions. We developed an integrated multivariate method, i.e. L2-normalization integrated positive matrix factorization (PMF) to analyze the high throughput biological and chemical data simultaneously and quantitatively evaluated the ability of PM2.5 to induce DEGs in relation to sources and meteorological conditions. PM2.5 from combustion related sources (e.g. traffic, power generation, industry, and biomass burning) and sea salt showed a stronger ability to induce DEGs than those from secondary aerosol source, and they are mainly associated with reproductive, developmental, and hormone related biological pathways. This suggests that more stringent controls on particulate emissions from combustion activities could effectively reduce the health impacts from PM2.5 pollution. The L2-normalization integrated PMF analysis of high throughput biological and chemical data could provide us a much more comprehensive understanding on the intrinsic toxicity of PM2.5 from various sources and aid the formulation of more targeted and optimized control measures to reduce PM2.5 pollution and its impact on environment and health.

Key words: PM2.5; heavy metals; control measures; health risk

Impacts of Ambient PM_{2.5} on Human Respiratory Epithelial Cells: Appropriate Choice of In Vitro Model

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Abstract:

In order to evaluate how the selection of an in vitro model may influence conclusions drawn from an inhalation toxicity study of ambient PM_{2.5}, this study exposes both undifferentiated human small airway epithelial cells (SAEC) and differentiated SAECs at air-liquid interface (S-ALI), to a mixture comprising a suite of compounds commonly found in smoke of burning various biomass fuels and urban PM_{2.5} (particulates smaller than and equal to 2.5 µm). Transmission electron microscopy (TEM) revealed that internalization of carbon black (CB) particles in differentiated S-ALI was appreciably less than that in undifferentiated SAEC. This phenomenon is likely due to the layer of mucus secreted by differentiated S-ALI which effectively traps the CB particles. This observation conforms to the results of the Trypan Blue Exclusion Assay, whereby the dose required to cause a statistically significant increase in cell non-viability is higher in differentiated S-ALI than in undifferentiated SAEC. After 24-hour treatment with reconstituted PM_{2.5}, both undifferentiated SAEC and differentiated S-ALI exhibited dose-dependent increase in cell non-viability. An in vitro dose of 13 µg/cm² resulted in a statistically significant increase in non-viable undifferentiated SAEC, whereas only doses above 22 µg/cm² caused a significant increase in non-viable differentiated S-ALI cells. Overall, the results of this study demonstrate the importance of using a more physiologically realistic S-ALI model rather than an undifferentiated SAEC model, so as to avoid over-stating the effects of inhaled particles on human health.

Particle deposition in a cell exposure facility: Is it comparable to the lungs?

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Abstract:

Cell exposure experiments at the air-liquid interface (ALI) are more and more used as indicators for health implications and biological endpoints as indicators for the impact of ambient aerosols on the lungs [1]. The advantages of such experiments are their relatively short duration, good repeatability and cost-effectiveness due to lab-scale facility dimensions. The exposure situation is supposed to be similar to the lungs, as particles stay airborne during the exposure experiment.

Geometry and air flow rates in the ALI deviate considerably from the human respiratory tract (RT). Deposition models for ALI and lungs [2, 3] are adopted here to mimic ALI and RT exposure and identify the differences. As cell lines from different parts of the RT can be used in an ALI system, the lung deposition software has to model the deposition in the extra-thoracic, bronchial and alveolar lung region on the basis of tissue-delivered dose.

Runs of particle deposition in both ALI and RT model are performed here for different particle size distributions. Their output is configured to provide the tissue-delivered particle deposition (TDD) per surface area of exposed cells per time. The dichotomous human lung structure [4] used in the RT model provides number, geometric diameter and length of the airway ducts and therefrom an estimate of their inner geometric surface area.

Results show the TDD in the ALI being up to two orders of magnitude higher than in the alveolar region, as the alveolar surface area in the deep RT is extremely high. In the bronchial region, however, it is roughly comparable. Interestingly, the TDD per single cell is nearly comparable between ALI and alveolar space, if type-I pneumocytes are taken into account as they are about 20-fold larger in size than type-II pneumocytes and as they contribute more than 95% to the cell count of the alveolar epithelium. The models do not include special effects like hot spots due to bifurcations or other sites of reduced bronchial clearance.

In conclusion, i) due to the high TDD, an ALI exposure experiment mimics the cumulated RT alveolar exposure of days; consequently, the experiment duration can be kept short and concentration low. And

ii) if the TDD in ALI and RT should be comparable, cell lines from the bronchial or extra-thoracic region should be used as biological targets.

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Study of Hazardous Air Pollutants in Fine Particles (PM_{2.5}) and the resulting cardiovascular and pulmonary toxicities, Research in Taiwan

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Abstract:

Previous studies have pointed out that Fine Particulate Matter (PM_{2.5}) can adversely affect human health, including cardiovascular disease (CVD), respiratory diseases and inflammatory reactions, and increase lung cancer mortality. Among the 22 heavy metal constituents of PM_{2.5}, we found that most of the components were positively associated with elevation of CVD risks. The results showed that heavy metals that have been known to be hazardous for human health (e.g. Aluminum, Nickel, Vanadium, Zinc, and Arsenic) were also positively associated with CVD in this Taiwanese population, after adjusting for age, sex, comorbidity, and PM_{2.5} mass concentration. The adjusted hazard ratio ranged from 1.11 to 1.22 (p-value < 0.05).

This study also investigated the distribution characteristics of PM_{2.5}-bounded water-soluble ion and PAHs at different areas in northern (U1 and E1), central (U2, E2 and R1) and eastern (U3 and R2) Taiwan. The real-time atmospheric samples collected in this project were extracted for water-soluble ions, metals, and hazardous air pollutants simultaneously. An in vitro cytotoxicity test was carried out to clarify the dose-response relationship of biological toxicity caused by particulate components. The PM_{2.5} concentrations measured in warm and cold season are 1.75 ± 1.3 - 27.4 ± 9.9 $\mu\text{g}/\text{m}^3$ and 3.74 ± 0.30 - 34.2 ± 17 $\mu\text{g}/\text{m}^3$, respectively. The concentration of PM_{2.5} bounded PAHs and BaP_{eq}-PAHs in industrial sites were significantly higher than urban and rural sites. The highest PAHs concentration occurred at E2 site, and the lowest occurred in background site. DR analysis results showed that sampling sites were related to liquid fossil fuel combustion of stationary and mobile emission sources. Based on the result of MTT assay which used A549 cell lines exposure different extract from PM_{2.5} to evaluate the cell viability. The organic extract causes stronger effects to cell viability, followed by water-soluble ions and

metal extracts. PM2.5 exposure concentration showed a dose-response relationship with cell viability. The results showed that organic extracts had the stronger oxidative stress effects (reactive oxygen species), followed by metal extracts and water-soluble ions. The results showed that PM2.5 organic extracts from E2, R1 and U3 stations in warm season had significant genotoxicity (measured by P450 CYP1A1 metabolism in TA1535/pSK1002 strain). PM2.5 extract in cold season is more hazardous to cell viability at E1 station. ROS test results showed that metal extract in cold season had significant oxidative stress even at low concentration. No genotoxicity effect was found from PM2.5 organic extract at E1 when effect of PM2.5 extract on cell viability at E2 station is the most significant. Both water-soluble ions and organic extracts produced significant oxidative stress, and PM2.5 organic extracts in warm season have significant genotoxicity; cytotoxicity and genotoxicity results of PM2.5 extracts were similar at R1 and U3 stations. In this study, a detoxification experiment was started to evaluate the compounds which can attenuate aerosol exposure effect on cell. A549 cell line enhanced the induction of CYP1A1 mRNA by benzo(a)pyrene with lily ethanol extract, which effectively reduced the increase of IL-6 and HO-1 mRNA induced by benzo(a)pyrene. However, Xiaoqinglongtang (a Chinese herbal medicine) extract has no such effect.

Screening of Hydrophobic Organic Components of PM_{2.5} Associated with Cellular Response of Inflammation and Oxidative Stress

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Peking University

Abstract:

Hydrophobic organics belong to the most complex components of ambient fine particulate matter (PM_{2.5}), and to reveal the most toxic components of PM_{2.5} is the key to set up the association between sources and health effects of this pollution. In this study, we screened and identified hydrophobic organic components of PM_{2.5} sampled during a one-year period from 2012/3 to 2013/3 in Beijing with gas chromatography-high resolution time-of-flight mass spectrometry (GC-TOF-MS) based on the cellular response of mouse macrophages, including intracellular reactive oxygen species (ROS) and secreted IL-1 β , IL-6, and TNF- α . Positive matrix factorization (PMF) analysis was performed to apportion the sources of identified components, and multivariate linear model (MLR) was applied to investigate the correlation between sources and cytotoxicity. This study set-up a non-targeted approach to screen the key toxic components in PM_{2.5} and identified mainly PAHs, methylated PAHs, oxygenated PAHs (oxy-PAHs; e.g. ketones and quinones), nitrogen-containing PAHs, and hopanes. The identified organic components have significant correlation with measured cytotoxic indicators especially IL-1 β . Oxy-PAHs showed a monotonic dose-response relationship with IL-1 β , while primary emitted species showed a U-shape dose-response relationship. Biomass burning, traffic emission, and secondary formation in the non-heating season, and coal combustion in the heating season are the major sources of identified species. It was found traffic emission was significantly correlated with ROS. Coal combustion and secondary formation were significantly correlated with mostly pro-inflammatory factors of IL-1 β , IL-6, and TNF- α , and biomass burning was significantly correlated with ROS and all pro-inflammatory factors, indicating both primary and secondary sources were all the important sources. In summary, this study found that components such as oxygen and nitrogen-containing PAHs, and methylated PAHs are probably more toxic to mouse alveolar macrophages than PAHs. Association between sources of these species and cellular response of oxidative stress and inflammation could provide further evidence to evaluate the health risk of air pollution.

Standardisation of Air-liquid Interface Exposures of Human Lung Cells using a Model Diesel Aerosol

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Abstract:

Background: The current discussions about combustion engines and manipulated diesel emissions calls more than ever for basic toxicology research, since it is undisputed that air pollution is associated with various diseases leading to increased premature deaths worldwide, but the “how” is not well documented. New regulations and new (synthetic) fuels will inevitably come and therefore there is a need for realistic in vitro exposure systems and appropriate exposure protocols, since it is still not possible to extrapolate emission characteristics directly to adverse health effects. Another aspect is that the aerosol toxicology community is in need of a model aerosol which can be used as a positive control that is comparable between research groups.

A cell exposure system (Vitrocell®) was combined herein with a soot generator (dieselCAST, Jing Ltd). This combination offers a unique opportunity, as i) it can be operated by few personnel, ii) particle size and organic fraction can be tuned reproducibly, iii) the exposure system offers a realistic exposure, i.e. whole aerosols (particles and gases) are applied to cell cultures at the air-liquid interface, and iv) particles deposit through diffusion, which is also the main mechanism in the human alveoli.

Aim: To investigate the in vitro effects of model particles and develop an optimized exposure protocol for the Vitrocell system.

Method: The dieselCAST was fueled with commercial German diesel and run with 50 µL/min. Characterization of the emission was done using different mass and particle counters as well as chemical analysis of the particles on filters. Porous tube- and ejector diluters were used to dilute the raw exhaust

Parallel Oral Session III

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

28 May 2019 (Tuesday) | 16:00 – 18:00

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Aerosol exposure and health (2) Co-chair(s) 1. Di Hu, Hong Kong Baptist University 2. Tomoaki Okuda, Keio University	Cynthia Isley, Macquarie University	Australia's lead in air standards are inadequate to protect children from lead poisoning	16:00-16:15	Mr and Mrs Lau Tat Chuen Lecture Theatre (LT-5)
	Yu-Lin Tseng, National Taiwan University	Effect of Lung Deposition on Fit Factor Measured Using Ambient Aerosols	16:15-16:30	
	Tuan-Hung Ngo, National Yang Ming University	Continuous Nationwide Atmospheric PCDD/F Monitoring Network in Taiwan(2006-2016): Carcinogenic risk assessment of atmospheric PCDD/Fs	16:30-16:45	
	Tomoaki Okuda, Keio University	Factors Responsible for the Biological Responses of Exposure to Atmospheric Fine and Coarse Particles Collected by Cyclone in Three Japanese Cities	16:45-17:00	
	Rafal Gorny, National Research Institute	Nasal lavage reactivity in workers of wood pellet production facilities exposed to particulate and microbial aerosols	17:00-17:15	
	Didier Goedertier, Philip Morris International R&D	Application and performance of the Capillary Aerosol Generator for rodent inhalation toxicology studies with e-vapor products	17:15-17:30	
	Sebastian Oeder, Helmholtz Zentrum München	In vivo and in vitro toxicity of emissions from a stationary diesel generator	17:30-17:45	
Bioaerosol (2) Co-chair(s) 1. Jean Jacques Godon, Laboratoire de Biotechnologie de l'Environnement 2. Naomichi Yamamoto, Seoul National University	Naomichi Yamamoto, Seoul National University	Taxonomic diversity of biological particles deposited from the atmosphere	16:00-16:15	Chan Kei Bui Lecture Theatre (LT-6)
	Senchao Lai, South China University of Technology	Characterization on aerosol proteinaceous matter in urban environment: a case study in Beijing during the 2014 APEC summit	16:15-16:30	
	Agata Stobnicka-Kupiec, Central Institute for Labour Protection – National Research Institute	Prevalence of viruses in bioaerosols of traditional dairies	16:30-16:45	
	Li Yihe, National University of Defense Technology	Long term bioaerosol monitoring by fluorescence spectroscopy over Changsha, China	16:45-17:00	
	Jean Jacques Godon, Laboratoire de Biotechnologie de l'Environnement	Towards passive sensors and mapping of areas impacted by local bioaerosol emissions	17:00-17:15	
	Ho Kin Fai, Chinese University of Hong Kong	Personal exposure to PM2.5 (and their constituents) and inflammatory responses in healthy young adults	17:15-17:30	
	Tangtian He, The Hong Kong Polytechnic University	Bacteria and antibiotic resistance genes in inhalable and exhaled fine aerosols	17:30-17:45	
Aerosol physics (2) Co-chair(s) 1. Chris Hogan, University of Minnesota 2. Thaseem Thajudeen, Indian Institute of Technology Goa	Chris Hogan, University of Minnesota	Examination of the Structures, Stabilities, and Extents of Hydration of Iodine Oxide/Iodic Acid Cluster Ions with Differential Mobility Analysis-Mass Spectrometry	16:00-16:15	SAE Magnetics Lecture Theatre (LT-9)
	Tommy Chan, University of Helsinki	Understanding the inversion methods from sub-3 nm particle number concentration data at two contrasting field sites	16:15-16:30	
	Tomoya Tamadate, Kanazawa University	Molecular dynamics study on charging process of aerosol nanoparticles	16:30-16:45	
	Hsi Chu Lin, National Taiwan University	Performance testing of virtual cyclone respirable sampler	16:45-17:00	
	Yuanping He, City University of Hongkong	Experimental measurement of charge on aerosol particles	17:00-17:15	
	Kaiyuan Wang, Tsinghua University	Piecewise Log-Normal Distribution for Representing the Size Distribution of Aerosol Particles	17:15-17:30	
	Alexander Shchekin, St Petersburg State University	What modern theory can say on the nonstationary formation and growth of submicron multicomponent aerosol droplets on nucleation stage?	17:30-17:45	
	Thaseem Thajudeen, Indian Institute of Technology Goa	Multidimensional characterization of non-spherical nanoparticles	17:45-18:00	
Aerosol chemistry (3) Co-chair(s) 1. Jun Zhao, Sun Yat-sen University	Sachin Gunthe, Indian Institute of Technology Madras (<i>Invited Speaker</i>)	Atmospheric Aerosols in Indian Perspective: Climate and Ecosystem Health Implications	16:00-16:30	Peter Ho Lecture Theatre (LT-10)
	Hai Guo, Hong Kong Polytechnic University	High-resolution analysis of organic aerosols in the atmosphere of Hong Kong with the application of TAG-GC-ToF-MS	16:30-16:45	
	Hoi Ki Lam, The Chinese University of Hong Kong	The effect of AS on the heterogeneous OH oxidation of methylglutaric acid: Kinetics and chemistry	16:45-17:00	

2. Hai Guo, The Hong Kong Polytechnic University	Jun Zhao, Sun Yat-sen University	A comparison of aerosol chemical composition under several different environments in China	17:00-17:15	Leung Ko Yuk Tak Lecture Theatre (LT-14)
	Nethmi Kasthuriarachchi, National University of Singapore	Effect of relative humidity on light-absorbing secondary organic aerosol formation in the evaporating droplets	17:15-17:30	
	Yongjie Li, University of Macau	Nitrate enhances near-UV/visible absorption of brown carbon (BrC) model compounds during aqueous-phase photolysis	17:30-17:45	
	Masao Gen, City University of Hong Kong	Electrospray-Surface Enhanced Raman Spectroscopy (ES-SERS) for Studying Organic Coating in Atmospheric Aerosol Particles	17:45-18:00	
Low cost sensor and sensor network (1) Co-chair(s) 1. Shih-Chun Candice Lung, Academia Sinica 2. Zhi Ning, The Hong Kong University of Science and Technology	Pratim Biswas, Washington University in St. Louis	Low-cost Sensors: Calibration and New Algorithms	16:00-16:15	
	John Watson, Desert Research Institute	Microsensor Comparison and Evaluation for Determining and Managing Area Source Emissions	16:15-16:30	
	Shih-Chun Candice Lung, Academia Sinica	Community Source Identification and Exposure-Health Evaluation with Low-Cost PM2.5 Sensors	16:30-16:45	
	Kang-Ho Ahn, Hanyang University	Test Method for a Low Cost Dust Sensor with Dynamically Changing Particle Concentration	16:45-17:00	
	Zhi Ning, The Hong Kong University of Science and Technology	City Wide Mobile Air Sensor Network (MASEN) In Hong Kong For Evidence Based Air Quality Management	17:00-17:15	
	Masami Furuuchi, Kanazawa University	Number Counting of Persons in a Focused Environment using a Portable Sensor detecting Wi-Fi Packet Signals from Mobile Phones	17:15-17:30	
	Houxin Cui, Hebei Sailhero Environmental Protection Hi-tech., Ltd	Low-Cost Air Quality Sensor Node Application to Pollution Management Systems in Chinese Cities	17:30-17:45	

Australia's lead in air standards are inadequate to protect children from lead poisoning

Cynthia Isley

Macquarie University

Mark Taylor, Macquarie University

John Glover, Torrens University

Abstract:

Background

Lead mining and smelting towns such as Broken Hill, Mt Isa and Port Pirie have a history of lead contamination and consequently of elevated blood lead levels in children.

Port Pirie has been the site of lead smelting operations since 1889. The soil in Port Pirie is contaminated with lead, accumulated over 130 years of emissions. Children in Port Pirie are exposed to lead from contact with soils, dust and lead-in-air.

Despite ongoing public health programs and environmental licencing and monitoring, in 2017, 47.4% of children tested in Port Pirie presented with a blood-lead level above the Australian intervention value of 5 $\mu\text{g}/\text{dL}$. Official health data show that from 2008–2017, 22.4% (mean of all years) of Port Pirie children presented with blood-lead exceeding 10 $\mu\text{g}/\text{dL}$.

Port Pirie children continue to remain at a significant risk from the effects of lead poisoning, including adverse impacts on IQ, academic achievement and socio-behavioural problems.

Method

Blood-lead and lead-in-air concentration data were analysed for the years 2003 to 2017. Lead in air samples were collected by the South Australian Environment Protection Authority using high volume air samplers, with lead determined by inductively coupled plasma optical emission spectroscopy. Blood-lead data were collected by South Australia Health using the finger-prick capillary technique and analysed by inductively coupled plasma mass spectrometer.

Regression analysis was performed to determine the relationship between the concentration of lead-in-air and in children's blood, both for children at 24 months of age and all children under five years old. Annual geometric mean data were used in each case.

Results

The modelled linear fits in Fig. 5 indicate that there is an underlying component of lead contamination in Port Pirie's children apart from atmospheric exposure. For children under five years old and 24-months

old, this level is modelled to be 2.7 $\mu\text{g}/\text{dL}$ and 3.0 $\mu\text{g}/\text{dL}$ respectively. This indicates that other sources such as exposure to soils and dusts (Maynard et al. 2006; Simon et al. 2007), as have already been well documented for Port Pirie, contribute to child blood-lead, with atmospheric exposure providing an additional exposure. In order for children's blood-lead to remain at or below 5 $\mu\text{g}/\text{dL}$, as a geometric mean across the population of Port Pirie, the model indicated that lead-in-air must be no more than 0.11 $\mu\text{g}/\text{m}^3$ for all younger than five years or 0.082 $\mu\text{g}/\text{m}^3$ when considering only children 24-months old.

Conclusion

The Australian lead-in-air standard is 0.5 $\mu\text{g}/\text{m}^3$ as an annual average; the Port Pirie smelter is obligated to comply with this. According to the modelled data, this standard is inadequate to protect children from elevated blood lead concentrations. In cities such as Port Pirie, where children are exposed to lead via multiple exposure pathways (soil, dust, air), further protections are required. By way of comparison, the United States EPA requires lead-in-air to not exceed 1.5 $\mu\text{g}/\text{m}^3$ as a 3-month average. A more stringent air quality standard would bring a reduction in the blood lead concentration of Port Pirie's children.

Effect of Lung Deposition on Fit Factor Measured Using Ambient Aerosols

Yu-Lin Tseng

National Taiwan University

Yu-Lin Tseng, National Taiwan University

Yu-Mei Kuo, Chung Hwa University of Medical Technology

Chih-Wei Lin, National Taiwan University

Sheng-Hsiu Huang, National Taiwan University

Abstract:

The quantitative fit test (QNFT) is required by US-OSHA to ensure the respirators provide a satisfactory seal between the contaminated area and the wearer, and to check if the respirator properly be donned prior to initial use. The fit factor (FF) is determined by the ratio of particle concentrations outside and inside the respirator. However, the results showed that the Portacount measurement might overestimate due to the incomplete mixing in the respirator cavity. However, the effect of aerosol deposition in the respiratory tract on the FF measurement was not characterized.

In this work, investigation of the fit factors was divided into three phases: (1) foam penetration test, (2) experimental testing using constant flow rate, and (3) simulation tests using a breathing machine (combination of tidal volume and breathing frequency). To simulate leakage on the respirator, capillaries with fixed 1.5 mm in length and variable diameter (1.0 -1.5 mm), were inserted between the facepiece and wearer's face. The ratio of total flow to leak flow was considered the 'true fit factor, FFt'. In Phase 1, foam penetration test was conducted in order to match the International Commission on Radiological Protection deposition model to simulate lung deposition. A scanning mobility particle sizer (SMPS) and an aerodynamic particle sizer (APS) were employed for aerosol penetration test. In Phase 2, the pressure drop corresponding to the leakage and filter flow rates at the constant flow rates of 5-40 L/min were measured. These data were then used to assess the amount of leakage during different breathing pattern, to estimate the FFt. In Phase 3, the effects of breathing pattern on in-mask particle concentration during fit testing were investigated. The correlation between the FF measured using ambient aerosols and the FFt was then analyzed.

The result showed the foam filter (packing density 0.03, fiber diameter 36 μ m and filter thickness 50 mm) has a good fit to the ICRP deposition model, when operated under face velocity of 100 cm/s. For the breathing simulation experiment, the fit factor of N95 was found to be overestimated compared to the FFt, because the filtered air was partly sampled during inspiration phase through sampling tube, which might dilute the particle concentration inside the facepiece. In addition, the fit factor might be further overestimated by Portacount, when tested under higher breathing flow rate, because of the

leakage increase due to flow re-distribution. Therefore, the fit factor measured by Portacount would not represent the worst cases. The correlation between the FFt and the Portacount measurement FF was established for better protection of the wearers.

Continuous Nationwide Atmospheric PCDD/F Monitoring Network in Taiwan(2006-2016): Carcinogenic risk assessment of atmospheric PCDD/Fs

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Abstract:

Background: Atmospheric polychlorinated dibenzo-dioxin/dibenzo furan (PCDD/F) is an indicator of environmental quality. In Taiwan, the annual atmospheric emission inventory of PCDD/Fs decreased from 88.6 g I-TEQ in 2006 to 57.8 g I-TEQ in 2016. Atmosphere is major emission matrix of PCDD/Fs from which pollutants could be transported and deposited in different areas. The contamination of PCDD/Fs in the air could lead to elevation of PCDD/Fs in other matrices. Therefore, it is important to quantify the how this source of PCDD/Fs influence the risk of developing cancer in people.

Objectives: Using dataset from Taiwan PCDD/F air monitoring network (2006-2016), we want to examine the exposure risk toward PCDD/Fs of people living in the island.

Methods: From long-term atmospheric PCDD/F measurements (n=1,008), we evaluated the concentration of PCDD/Fs in each matrix (including deposition, soil, water and sediment) and in daily food (including vegetable, fruits, rhizome, rice, beef, milk, pork, chicken, eggs, and fish). All the calculation was based on Multimedia Environmental Pollutant Assessment System (MEPAS) developed by United States Environmental Protection Agency.

Results and Discussion: PCDD/F concentrations gradually decreased during study period with eleven-year median concentration of 28.2 fg I-TEQ/m³. The highest PCDD/F concentrations in Taiwan were found in areas with high industrialization level in the west (38.0-43.4 fg I-TEQ/m³) when the least industrialized areas in eastern parts of the island had concentration of just over 10 fg I-TEQ/m³. The median deposition rate of PCDD/Fs in Taiwan ranged from 1.99 to 7.49 pg I-TEQ/m²-yr. The median concentration of PCDD/Fs in soil and sediment matrices were found to be 0.10 – 0.37 ng I-TEQ/kg and 0.02 – 0.06 ng I-TEQ/kg, respectively. The highest contents of PCDD/Fs were found in beef (0.04-0.151 pg TEQ/g), pork (0.033-0.125 pg TEQ/g), rice (0.029-0.108 pg TEQ/g), and eggs (0.024-0.092 pg TEQ/g). The lifetime average daily doses (LADD) of PCDD/Fs in Taiwan ranged from 3.41×10⁻³ to 1.27×10⁻² pg I-TEQ/kg/d, which were lower than the WHO regulation (1-4 pg TEQ/kg/day). The median carcinogenic risk of exposing to PCDD/Fs in overall Taiwanese population was found to be 8.55 x 10⁻⁷, which is

smaller than the threshold of carcinogenic risk for long term exposure to PCDD/Fs of 10^{-6} (US EPA). However, the median carcinogenic risk due to PCDD/Fs exceeded the tolerance dose in highly industrialized areas namely, Central area (1.17×10^{-6}), Southwestern area (1.33×10^{-6}), and Southern area (1.24×10^{-6}). The exceeded standard carcinogenic risk was found in the western part of the island including Central area (1.17×10^{-6}), Southwestern area (1.33×10^{-6}), and Southern area (1.24×10^{-6}) even the estimated exposure doses were all lower than WHO tolerance threshold.

Keywords: PCDD/Fs, POPs, Atmospheric, Carcinogenic Risk Assessment

Factors Responsible for the Biological Responses of Exposure to Atmospheric Fine and Coarse Particles Collected by Cyclone in Three Japanese Cities

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Abstract:

Many epidemiological studies showed that particulate matter exacerbates respiratory and immune health such as allergic rhinitis and bronchial asthma in addition to cardiovascular diseases. However, the difference in the effects of particulate matter on respiratory tract and immune responses have not yet been clarified. Moreover, the components of particulate matter responsible for the adverse health effects have not yet been elucidated. Generally, cell exposure studies for aerosol particles have been conducted using particulate matter collected and extracted by vibrating aerosol-loaded filters. However, the particles used for the exposure study may not be the same as those present in ambient air. Possible contamination from the filter material should also be considered. In addition, sample handling to obtain particles for exposure experiments is highly complicated and time-consuming. Besides, the amount of particles that are collected on a filter is often insufficient to perform an exposure studies. Hence, techniques that allow researchers to collect a sufficient amount of aerosol particles for exposure studies without the use of filters or extraction should be developed. In this study, we developed a high-volume simultaneous sampler for fine (PM_{2.5}) and coarse aerosol particles using the impactor and cyclone

techniques. Approximately 100 mg of fine and coarse aerosol particles can be collected individually as powder form for 2-3 week sampling. The sampling device developed in this study allows researchers to collect a sufficient amount of aerosol particles for cell exposure studies without the use of filters. We collected fine and coarse aerosol particles in three cities (Yokohama, Saitama, and Fukuoka) in Japan under the CYCLEX (Cyclone collection of PM_{2.5} followed by Exposure Experiments) project. The site Fukuoka is the closest city to the Asian Continent among our three sampling sites. Chemical analysis (about water soluble ion, metal, Carbon) of the collected particles has been carried out followed by cellular exposure experiment. Inflammatory responses on the human bronchial epithelial cells induced by ambient and reference particles were examined¹). As the result, the particulate matter collected by our cyclone increased the production of IL-8 from bronchial epithelial cells, in compare to the control. The inflammatory response was stronger in Yokohama and Saitama, but it was relatively weak in Fukuoka. This result seems corresponded to the difference in chemical features of aerosol particles among these three sites.

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Nasal lavage reactivity in workers of wood pellet production facilities exposed to particulate and microbial aerosols

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Abstract:

Occupational exposure to airborne wood dust and bioaerosols may lead to numerous respiratory tract diseases. The aim of this study was to evaluate air contamination with particulate and microbial aerosols during wood processing at pellet factories and to assess to what extent the levels of pro-inflammatory markers and cytological image of nasal lavage (NAL) collected from workers reflects their degree of such exposure.

This study was carried out in 10 wood pellet plants in Poland. At each studied workplace, aerosol samples were collected during 8-hour shift at a height of 1.5m above floor level to simulate aspiration from the human breathing zone. Particulate (wood dust) aerosol concentrations were assessed using Grimm optical counter and conical inhalable sampler (CIS). Additionally, after gravimetric analysis of wood dust mass from CIS filters, the collected aerosol particulates were analyzed to determine endotoxin and 1β -D-glucan concentrations using Limulus Amebocyte Lysate and GlucateLL kinetic assays, respectively. Simultaneously with particulate aerosol, bioaerosol samples were collected using 6-stage Andersen and 1-stage MAS impactors. Bacterial and fungal aerosol concentrations were calculated and isolated microorganisms were taxonomically identified based on their morphological, biochemical and molecular features. To investigate causal relationships between aerosol exposure and adverse health effects among workers, NAL fluid samples were collected and the concentrations of pro-inflammatory mediators (interleukins IL-1 β , IL-6, IL-8 and TNF α) and a cytological image of the nasal mucosa expressed as (total, epithelial and lymphocyte) cell counts were established.

The study revealed that the average airborne wood dust concentrations measured with CIS and Grimm samplers were 8.52mg/m³ and 1.87mg/m³, respectively. The total of 78% and 56% samples crossed the Polish threshold limit values (PTLVs) established for soft (>2mg/m³) and hard (>4mg/m³) wood dust. The average bacterial and fungal aerosol concentrations measured with MAS as well as Andersen impactors were 2018cfu/m³ and 564cfu/m³ as well as 1078cfu/m³ and 428cfu/m³, respectively, and did not cross the PTLVs (i.e. 100,000cfu/m³ and 50,000cfu/m³) established for working environment

contaminated with organic dust. Also average airborne endotoxin concentration of 38.4ng/m³ was below PTLV (i.e. 200ng/m³). The average airborne 1,3-β-D-glucan level was 458ng/m³; however, for this pollutant the TLV was not so far established. The most prevalent microbial groups in the air were Gram-positive cocci and filamentous fungi. Among isolated microorganisms, human pathogens from *Streptomyces* and *Aspergillus* genera were identified. Taking into account bioaerosol size distribution, inhalation of microbial propagules may result in eye and nose irritations as well as in allergic alveolitis type of reactions. The average concentrations of pro-inflammatory mediators in NAL for IL-1β, IL-6, IL-8 and TNFα were 1.7pg/ml, 0.5pg/ml, 45.3pg/ml and 1.6pg/ml, respectively, whereas average numbers of total, epithelial and lymphocyte cells were 4#/ml, 3#/ml i 1#/ml. Correlation analysis showed that the levels of pro-inflammatory mediators and the number of cells in NAL were significantly affected by both wood dust and bioaerosol concentrations. Environmental stress caused by exposure to their high concentrations was reflected in the stimulation of appropriate immune response among exposed workers. It confirms that NAL is a reliable analytical material in assessing aerosol exposure.

Application and performance of the Capillary Aerosol Generator for rodent inhalation toxicology studies with e-vapor products

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Abstract:

The Capillary Aerosol Generator (CAG) concept was developed nearly twenty years ago finding various applications including generation of pharmaceutical aerosols. We have developed our own setup for a compact generation, dilution and delivery of aerosols generated from the CAG. The objective of these developments was to establish and characterize a system for continuous aerosol generation from liquid mixtures present in e-vapor products for rodent inhalation exposure. These liquid mixtures contain aerosol formers (propylene glycol, glycerol), water, nicotine and frequently flavor mixtures.

The physical process of aerosol generation from liquid mixtures in the CAG is complex and follows various stages with varying thermodynamic conditions. First, the liquid is supplied via the pump to the capillary at a controlled flow rate. The operating capillary temperature is in the range of boiling temperatures of mixture constituents depending on the composition: between 100°C (water boiling point) to 290°C (glycerol boiling point). The liquid is continuously heated beyond the boiling point of the mixture causing bursts of generated vapors to be discharged from the capillary outlet at the temperature and pressure dictated by the thermodynamic conditions. Then, the supersaturated vapors are cooled down with the ambient cold air stream by vigorous often turbulent mixing around the capillary outlet, triggering nucleation processes and subsequent condensation. Thermodynamic, physical and chemical properties and conditions of the mixture such as surface tension, temperature, saturation, equilibrium vapor pressures and gas phase concentrations of the constituents are important to obtain

controlled and continuous aerosol delivery at the required concentration and particle size distribution. For inhalation purposes the generated aerosol is often diluted to control the delivered dose of constituents further contributing to the complexity of the overall aerosol generation process.

We tested our system in numerous configurations including liquid mixture supply ranging from 0.2 to 1.0 ml/min, setting various capillary temperature values in the range of 200 to 300°C, imposing ambient cold streams for aerosol nucleation in the range of 10 to 100 l/min, and subsequently diluting the aerosol with fresh filtered process air to reach the desired aerosol concentration for the inhalation exposure. It was determined that at the capillary temperature of 250°C with an ambient cold stream of 10 l/min, particle size with a mass median aerodynamic diameter below 1.5 µm was achievable. The aerosol was further diluted to reach the final target concentration of the aerosol constituents. With our experimental work we have demonstrated that the CAG can be used for the continuous aerosol generation with consistent particle size distribution and refined concentrations suitable for rodent inhalation studies.

In vivo and in vitro toxicity of emissions from a stationary diesel generator

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Abstract:

Emissions from diesel engines contribute significantly to ambient air pollution worldwide. Epidemiological studies show many adverse health effects related to the exposure with diesel exhaust emissions (DEE) like increased risk of lung cancer, or an increase in cardiovascular morbidity and mortality. A proposed mechanism by which DEE exerts these effects is that diesel exhaust particles (DEP) are inhaled and cause a local inflammation in the lung. This triggers a local secretion of pro-inflammatory molecules. Upon prolonged or severe exposure to DEP, the excess of these molecules is then released into the blood stream. There they can cause systemic inflammation and oxidative stress, which in turn can lead to cardiovascular impairment. DEE and DEP can also contribute to the formation of lung carcinomas through DNA oxidation or direct DNA damage because of their high content of polycyclic aromatic hydrocarbons (PAHs) or deposition of particles.

In this study, we analyzed DEE from a stationary diesel engine, which is mainly used as a mobile electricity generator or in small construction machinery. We characterized the emissions' physicochemical properties both online and offline and assessed the toxic potential of the DEE with state-of-the-art in vitro and in vivo exposure systems. The amount of DNA-damage was assessed by COMET-assay, changes in the vital metabolic pathways were determined on proteome and transcriptome level. Also, immunohistochemical staining of lung slices and cells in the bronchoalveolar fluid (BALF) was carried out. The engine was operated in a four-hour test cycle with representative engine loads. Exposures of the mouse macrophage cell line RAW264.7 and the human alveolar epithelial cell line A549 were performed at the air-liquid interface (ALI). The mice were exposed in a whole body inhalation chamber to the DEE.

The average particle number concentration in the DEE was $4.1 \pm 1.6 \times 10^6$ particles/cm³. The DEP had a low content of organic compounds, which was dominated by the mid-range oxygenated polycyclic aromatic hydrocarbons (PAHs) 9H-Fluoren-9-one and 1,8-naphthalic anhydride, as well as other PAH compounds like phenanthrene, fluoranthene and pyrene. Both in A549 and RAW264.7 cells we found that several important pathways were regulated, most of which are related to oxidative stress, inflammation and activation of immune cells, as well as mitochondrial dysfunction, regulation of transcription and molecular signalling disturbance in general. In the COMET-assay we observed that exposure to DEE significantly increased the extent DNA-damage in both A549 cells and in vivo in BALF and lung tissue. The amount of DNA-damage was between five and eight times higher in the DEE-exposed cells and animals than in controls exposed to clean filtered air. Immunohistochemical staining of BALF cells showed that DEP had accumulated inside the cells indicating active phagocytosis of DEP by immune cells in the lung. We found that both the amount of matrix metalloproteinase-12 and galectin-3 was increased in macrophages in the lung tissue of DEE-exposed mice compared to untreated control animals. Overall, both the in vitro and in vivo results suggest that exposure to DEE from a stationary diesel engine causes severe cytotoxic, genotoxic and fibrotic damage.

Taxonomic diversity of biological particles deposited from the atmosphere

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Abstract:

Biological particles such as bacterial cells, fungal spores and plant pollens suspended in the atmosphere are eventually deposited to the surface of the Earth by sedimentation (dry deposition) and precipitation (wet deposition), which contributes to the global cycling of substances. However, knowledge is scarce about taxonomic diversities of biological particles deposited from the atmosphere. In this study, we used an automatic dry and wet deposition sampler and high-throughput sequencing plus quantitative PCR to analyze taxonomic diversities and flux densities of biological particles deposited from the atmosphere. The deposition velocities and aerodynamic diameters (d_a) were also determined by a collocated cascade impactor for particle-size-resolved, volumetric air sampling. Several key findings of this study include that taxonomic compositions of plant pollens deposited from the atmosphere were patterned by season rather than by the forms of atmospheric deposition; and that taxonomic compositions of fungal spores deposited from the atmosphere were strongly patterned by the forms of atmospheric deposition (i.e., dry vs. wet). Specifically, we found that large multicellular spore-producing dothideomycete fungi ($d_a \geq 10.0 \mu\text{m}$) were found to be abundant in dry deposition while small spore-producing agaricomycetes ($d_a < 5.0 \mu\text{m}$), including mushroom-forming fungi, and sordariomycetes, including plant pathogenic species, were enriched in wet deposition, indicating that these spores serve as nuclei in clouds, and/or are discharged preferentially during precipitation. Overall, our study demonstrates taxon-specific involvements of atmospheric biological particles in the Earth's material cycles including the water cycle.

Characterization on aerosol proteinaceous matter in urban environment: a case study in Beijing during the 2014 APEC summit

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Abstract:

Proteinaceous matter including proteins (i.e., combined amino acids, CAAs) and free amino acids (FAAs) consists of a substantial part of atmospheric particles, contributing up to 5% of the mass of atmospheric aerosol. Aerosol proteinaceous matter may affect aerosol physical and chemical properties, atmospheric chemistry and climate from local, regional to global scales as well as human health. We present an observation of Aerosol proteinaceous matter in fine particulate matter (PM_{2.5}) samples urban Beijing during 2014 Asia-Pacific Economic Cooperation (APEC) summit. The total proteins, total CAAs and total FAAs concentrations exhibited similar temporal variations to those of major chemical components with lower levels during APEC than those before APEC. Glycine (Gly) and alanine (Ala) were the most two abundant CAA species in both periods. Among FAAs, Valine (Val) and Gly were the predominant species in non-APEC and APEC periods, respectively. The temporal variations of total proteins, CAAs and FAAs are investigated and the sources in urban Beijing with and without source control measures will be shown in this contribution. The influence of source control measures and meteorological conditions is further studied. Moreover, analysis and discussion on atmospheric processes of major FAAs will be presented in this contribution to provide new insights into aerosol proteinaceous matter in metropolitan environment.

Prevalence of viruses in bioaerosols of traditional dairies

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Abstract:

Bovine leukemia virus (BLV), belonging to the Retroviridae family, affects dairy cows in the worldwide population. Most animals remain clinically healthy, however they can shed viral particles with body fluids, including milk. Recent studies suggest that BLV may be harmful for humans, due to their many structural and functional features in common with human T-lymphotropic viruses. Many studies indicate that workers exposed to viruses in the working environment, e.g. on dairy farms, have a higher risk of developing hematopoietic neoplastic diseases, including acute myeloid leukemia (AML) and acute lymphocytic leukemia (ALL). Bovine Adenovirus (BAdV) belonging to Adenoviridae family is widespread all over the world. Infection may not always result in disease, so the virus can be isolated in healthy cattle. BAdVs are shed with respiratory secretions and faeces, thus they were proposed as bovine fecal markers in food processing.

Bioaerosols samples were collected in summer in traditional dairies, where many production activities were performed manually, involved in the processing of raw cow's milk into products such as: cottage cheese from fresh milk, rennet cheese from fresh milk, cream and butter. Thirty seven bioaerosols samples were collected on selected measurement points included: milk reception area (6), milk storage area (6), cottage cheese production hall (8), rennet cheese production area (8), butter and cream production area (5) and packaging area (4). Air sampling was carried out stationary, using the volumetric method with the MAS-100 impactor on the bi-phase medium containing as solid phase MBA agar medium (Mycoplasma base agar) (Oxoid, England) and as liquid medium Selective Supplement-P (Oxoid, England).

The aspiration time was equal 20-minute, with the flow rate 100L/min. Viral RNA and DNA were extracted with Viral Mini Kit PLUS (Syngen, Poland). Detection and quantification (PCR-detectable units PDU) of BLV and BAdV were carried out using commercial kits: Bovine leukemia virus v1.1 pol gene genesig™ Advanced Kit and Bovine Adenovirus 5/6/8 hexon gene genesig™ Advanced Kit (Primerdesign™ Ltd).

RT-qPCR/q-PCR based studies showed the presence of BLV and BAdV genomes in bioaerosols from traditional dairies. Overall, 16.2% samples were positive. Among them 67% of samples were BLV-

positive, while 33% BAdV-positive. Co-contaminated bioaerosols represent 5.4% of the total tested samples. Statistical analysis showed that analyzed samples were significantly more contaminated with BLV genomes than with BAdV ones (χ^2 $p < 0.05$, Fischer Exact test $p < 0.05$). The highest average concentration of BLV (20 PDU/m³) and BAdV (11 PDU/m³) were observed in bioaerosols from the milk reception area. Concentrations of BLV and BAdV genomes in bioaerosols of the pre-production area (milk reception area, milk storage area) were significantly higher in comparison with concentrations of these viral agents in samples from the production area (cottage cheese production area, rennet cheese production area, cream and butter production area, packaging area) ($p < 0.05$).

Based on this study, it can be concluded that viruses derived from the cattle may be present in the dairies and play potential risk for workers. Presence of BAdV may be also treated as fecal marker, which can indicate potential fecal contamination of processed products.

Long term bioaerosol monitoring by fluorescence spectroscopy over Changsha, China

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Abstract:

Bioaerosol monitoring is a hot-spot in the fields of ecology, healthy and safety. Compared with traditional off-line detection (non-culture-based-methods), on-line monitoring method is faster and more accurate, such as fluorescence spectroscopy. The correlations between bioaerosol and meteorological factors were proven. A number of works have been done to study the correlation between bioaerosols' fluorescence intensity and individual meteorological factor, however, there are few researches on overall correlation. In addition, there're data gaps of long-term aerosol fluorescence monitoring in South Central China.

This work aims to establish multiple regression models and neural network models of major factors such as fluorescence intensity and meteorological factors, the study measured using a new Fluorescent Data Acquisition Instrument (FDAI) by a length of six months, FDAI can identify fluorescent biological aerosol particles (FBAPs) by fluorescence characteristics, the emission is followed by a 266nm excitation and recorded in the 405nm waveband.

FDAI measurement was performed in Changsha, China (28°15'N, 113°02'E; 60m a.s.l). The FDAI inlet was placed on the fourth floor of the laboratory, i.e. approximately 15m above the ground. The measurement site is surrounded by the northern plains and 310 metres from a crossroads on the south. We obtained additional precipitation, temperature, humidity, wind speed, air pressure data from the Tuanjie-yuan Weather Station of Changsha Meteorological Bureau located about 2.8 kilometres to the northeast of the measurement site. FDAI samples the ambient is continuously over a period of six months (1 Nov 2018-1 May 2019).

By the measured fluorescent data, we employ regression analysis to control the independent variable effectively and eliminate meteorological factors that have no significant effect on fluorescence intensity, and retain independent variables with significant influence, at the same time, use fluorescence intensity

and meteorological factors to train the neural network and test the simulation accuracy. We hope to find a pattern to establish a more reliable and accurate multiple regression model and neural network model, and these're what we want to show at the conference.

Our findings indicate the urgent need for more accurate methods to determine the correlation of bioaerosol with meteorological factors to enhance our understanding of bioaerosol monitoring. To our best knowledge, this study is the first long term recording to monitor bioaerosol by fluorescence spectroscopy in South Central China, which provides data into the research of fluorescence intensity and meteorological factors' overall correlation.

Towards passive sensors and mapping of areas impacted by local bioaerosol emissions

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Abstract:

Bioaerosols can emanate from composting plants, microalgae cultivation, livestock, and wastewater treatment plants, among others. By their biological nature, bioaerosols are potential vectors of pathogens or toxins and thus can have a health impact on residents and workers. They can also have an ecological and economic impact in case of for example contamination of farms and production sites of fish, crustaceans, shellfish and microalgae.

Currently used bioaerosol sensors are of the volumetric 'instantaneous' type that sample during short periods of time. These sensors cannot take into account the multiple settings that determine the bioaerosol dispersion and the impacted area. These parameters are variations in the level of emissions, weather conditions (sunshine, temperature, humidity, etc.) and the topography of the site. Since the proper tools are lacking, it is currently not possible to map the areas impacted by bioaerosol emissions and determine the impact levels. To overcome these limitations, we developed the concept of passive sensors for the environmental monitoring of bioaerosols.

In a first trial, we used pine needles as collection surface of bioaerosols released by a composting plant located in the South of France. We quantified the microbial compost indicator *Saccharopolyspora rectivirgula*. Samples were collected at distances ranging from 100 m to 4000 m around the composting plant. The 16S rDNA abundance from *S. rectivirgula* and the total bacteria were measured by qPCR to indicate the impact of composting plant bioaerosols. The abundance of 16S rDNA of *S. rectivirgula* varies from 10² to 10⁴ copies per gram of *P. halepensis* needles.

A map of impacted area has been drawn, showing that the abundance of *S. rectivirgula* on *P. halepensis* needles were negatively correlated with the distance to the point source. Topography and prevalent wind direction had an influence on the dispersion pattern. The abundance of indicator organism reached background level at distances ranging from 2 km to more than 5.4 km from the composting plant.

As the pines are not available everywhere, a second trial was performed using bottlebrushes to mimic pine needles. Bottlebrushes located close to a bioaerosol emission source (microalgae pond) collected

over time showed an accumulation of bacteria and microalgae. Accumulation level was similar between pine needles (indeterminate time) and bottlebrush (up to 20 days).

Thus, we now have the tools necessary to draw a map of the areas impacted by any source of bioaerosols. To do that we need (i) the analysis plan (relevant distance between the source and the sensor), (ii) a sensor (bottlebrushes), (iii) a specific microbial indicator (depending on the bioaerosol source), (iv) a qPCR measuring system (specific to the indicator).

Personal exposure to PM_{2.5} (and their constituents) and inflammatory responses in healthy young adults

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Abstract:

Given the lack of research on the personal exposure to fine particles (PM_{2.5}) in Hong Kong, the association between short-term personal exposure to PM_{2.5} (and their constituents) and inflammation in exhaled breath were examined in a sample of healthy adult residents.

Forty-six participants underwent daily personal PM_{2.5} monitoring for 6 days to obtain 276 samples. Fractional exhaled nitric oxide (FeNO), a biomarker of inflammation in exhaled breath, was measured at the end of each personal air monitoring. PM_{2.5} chemical constituents, including organic carbon, elemental carbon, 16 polycyclic aromatic hydrocarbons (PAHs), and 6 phthalate esters, were determined. A mixed-effects model was used to estimate the association of PM_{2.5} and their constituents with FeNO. The comparison was also made with parallel analyses using ambient concentrations. Personal exposures to PM_{2.5} ($28.1 \pm 23.3 \mu\text{g}/\text{m}^3$) were higher than the ambient levels ($13.3 \pm 6.4 \mu\text{g}/\text{m}^3$) monitored by stations. The composition profile and personal-to-ambient concentration ratio varied among subjects with different occupations. An interquartile range (IQR) change in personal exposure to PM_{2.5} was positively associated with 12.8% increase in FeNO (95% confidence interval, CI: 5.5–20.7%), while nil association was found for ambient PM_{2.5}. Among the constituents measured, only the carcinogenic PAHs (c-PAHs) were significantly associated with 12% increase in FeNO responses (95% CI, 0.0–25.6%).

Bacteria and antibiotic resistance genes in inhalable and exhaled fine aerosols

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Abstract:

Fine particulate matter (PM_{2.5}) has been recognized as a key intersection where two public health challenges merge, namely air quality and antimicrobial resistance. Airborne transmission of antibiotic resistance genes (ARGs) and host bacteria via PM_{2.5} has strong implications for inhalational exposure to these potential microbial hazards. Exhalation as part of the bi-directional breathing process eliminates microorganisms and volatile organic chemicals via the outgoing air flow. On one hand, characterization of bacteria communities and ARG profiles in inhalable ambient particles and exhaled breath enriches our understanding of the microbial components of fine aerosols at the human-atmosphere interface. On the other hand, airborne transmission of ARGs via these fine aerosols in and out fills in a missing piece of the jigsaw puzzle about the environmental dissemination of antimicrobial resistance.

To reveal the spatiotemporal features of airborne bacteria and ARGs in inhalable fine aerosols, we undertook an extensive PM_{2.5} sampling in three representative regions from northern to southern of China, namely Beijing (two urban sites), the Yangtze River Delta (YRD; industrial-urban-rural), and the Pearl River Delta (PRD; urban-suburban-semirural). Larger seasonal variations of bacteria and ARG abundances were observed in temperate Beijing than in the subtropical YRD and PRD regions. The ARG profiles within each region was relatively stable independent of seasonal cycles and land-use gradients. Despite regional differentiation in bacterial communities, there appeared to be limited bacterial genera

that were associated with the ARGs across the regions, suggesting common core taxa members as potential ARG hosts.

To investigate the potential link in ARGs and bacteria between inhalable and exhaled fine aerosols, we conducted simultaneous sampling of parallel ambient PM_{2.5} and human exhaled breath condensates (EBC). Our pilot study revealed similar bacterial resistance profiles based on the limited set of resistance subtypes analysed so far between PM_{2.5} and EBC. It is interesting to note both PM_{2.5} and exhaled breath representing the human-atmosphere interface were ranked at the higher end of ARGs enrichment compared to the other matrices at the human-surface environment interface. Total ARGs significantly correlated with mobile genetic elements in PM_{2.5} across most of the land-use types and in exhaled breath, hinting at the mobility potential of ARGs from the atmosphere to the human airway.

With respect to human exposure to ARGs, we identified the region-specific importance of PM_{2.5} inhalation in China as well as country-specific exposure scenarios by comparing the daily intake of ARGs via PM_{2.5} inhalation and other contributing pathways (e.g., drinking water and food ingestion). With respect to human releases of antimicrobial resistance, the total daily emission of Class 1 integrons via exhalation is comparable to that via fecal excretion.

Our study thus highlights the significance of inhalation in the aggregate exposure pathways of environmentally-disseminated ARGs and of exhalation as a human source of ARGs into the ambient air, thus forming a loop at the human-atmosphere interface. Quantifying the flow and evolution of ARGs and resistant bacteria along the loops at the human-atmosphere and human-surface environment interfaces strengthens the connecting link between the environmental and clinical dimensions of antimicrobial resistance.

Examination of the Structures, Stabilities, and Extents of Hydration of Iodine Oxide/Iodic Acid Cluster Ions with Differential Mobility Analysis-Mass Spectrometry

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Abstract:

Previous studies (O'Dowd et al 2002; Sipila et al 2016) have shown that clustering reactions with iodic acid (HIO₃) to yield iodine oxide clusters of the form (I₂O₅)_x(HIO₃)_y, contribute to new particle formation in coastal regions. Examination of the structures, stabilities, and extent of hydration of such clusters near ambient temperatures and pressures is hence of interest in developing an improved understanding of how such clusters can grow to stable particles from vapor phase precursors. We have utilized high resolution parallel-plate differential mobility analysis in tandem with time-of-flight mass spectrometry to examine the collision cross sections in CO₂ bath gas of 15 chemically identified negatively charged cluster ions of the form (I₂O₅)_x(HIO₃)_y(IO_z)⁻ with $x = 0 - 7$, $y = 0-1$, and $z = 1-3$. Collision cross section measurements were made at ambient pressure, and at variable relative humidity levels. Measurements reveal that such clusters remain relatively stable in mass spectrometer inlets, with a substantial fraction of parent ions surviving the high pressure to low pressure transition. Comparison of measurements to collision cross section predictions (using IMOS, Larriba & Hogan, 2013) based upon quantum-chemical computation-derived-structures shows that CO₂ scattering from cluster surfaces is largely diffuse. Finally, we observe that the collision cross sections of the examined ions shift only by 10% when exposed to water vapor at relative humidities as high as 60%. This suggests that clusters remain largely composed of di-iodine pentaoxide at low relative humidities, but do uptake water and potentially convert to predominantly iodic acid at elevated relative humidities.

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Understanding the inversion methods from sub-3 nm particle number concentration data at two contrasting field sites

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Abstract:

Number-size distribution of atmospheric aerosol particles in the size range between 1-3 nm is extremely important to understand for its contribution to growth, nucleation and formation to clouds and new particles. One challenge using these instruments is the inversion method used to identify the correct size distribution from measured number concentration. This challenge is evident with the particle size magnifier (PSM), which determines the particle size distribution upon on the relationship between the particle number concentration and the varying saturator flow rate. The resulting size distributions can vary greatly from one another – in the range of about 2-3 orders in magnitude. Although the uncertainties of the size distribution and during data inversion have been explored, the application of these principles in real-world environments have not yet been studied.

Prior to any data inversion, we introduce new method to discard measured data that is deemed bad. Specifically, a p-value statistical test is used to identify scans that are bad, due to updraft of wind into the inlet, for example. A scan is a 4-minute increase and decrease of the saturator flow rate, from 0.1 litres per minute to 1.3 litres per minute. Four inversion methods are studied: step-wise, kernel, Hagen & Alofs and the expectation-maximization method. In this study, we measured ambient data using the PSM at two sites: Beijing University of Chemical Technology, in Beijing, China; and Hyytiälä Forestry Field Station in southern Finland. The former is in central Beijing, and indicative of an urban environment, while the latter site is indicative of a boreal forest environment. We will focus on several event-types at each location (if applicable), such as: new particle formation, non-event and haze. These two dissimilar

sites allow for ideal understanding of how data handling and inversion of sub-3 nm particles affect data quality measured in ambient conditions.

Keywords: aerosol particles, particle size magnifier, inversion methods, sub-3nm

Molecular dynamics study on charging process of aerosol nanoparticles

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Abstract:

Charging of aerosol is an important process to electrostatically control particles' motion in the gas phase. In this study, charging process of electrosprayed highly charged molecular ions and nanoparticles was investigated. Polyethylene glycol (PEG) with monodispersed molecular weight was used as a test molecular ions. Mass and mobility (charge) distributions of the PEG ions were characterized experimentally using ion mobility and mass spectrometry (IMS/MS). It was found that the electrosprayed PEG ions were highly charged and with a variation of molecular structure from spherical to stretched conformations depending on charge state. These molecular conformations were validated by molecular dynamics (MD). Then, as counter ions, atmospheric ions were generated by radioactive or plasma ion sources. Charge reduction (neutralization) process of these highly charged PEG ions with interactions with atmospheric ions was investigated by comparing experimental data, diffusion charging theory and MD simulation results.

Performance testing of virtual cyclone respirable sampler

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Abstract:

Respirable dust is known to pose threat to workers, resulting in lung destruction and other adverse health effects. Previous studies have shown that most of the respirable samplers can only meet the 50% cut-point, but not the slope of the international ACGIH/ISO/CEN/NIOSH respirable convention. In addition, most of the currently commercially available samplers suffer from aerosol loading effect, which causes the separation efficiency curve of the samplers to shift to smaller aerosol size as sampling proceeds and, therefore, underestimate the concentration of respirable dust. Thus, a virtual cyclone without loading effect was developed and validated in the present study.

An ultrasonic atomizer was used to generate micro-meter-sized PST challenge aerosols. A syringe pump delivered the PST solution to the ultrasonic atomizer. A radioactive source, Am²⁴¹, was used to neutralize the particles to the Boltzmann charge equilibrium. Both virtual cyclone and 10mm nylon cyclone were used for size-selective sampling. An aerodynamic particle sizer was used to measure the particle size distributions and number concentrations upstream and downstream of the respirable aerosol samplers, to obtain the separation efficiency curve. The filter sample was used to validate the mass concentration in the test chamber.

The virtual cyclone was equipped with an inlet width of 20mm, inlet height of 0.35mm, and sampling flow rate of 5.5 L/min. The aerosol penetration curve fits perfectly to the international convention, with no aerosol loading effect during sampling period. The dust collected by Teflon filter was viewed as the total dust, and respirable dust was estimated as a portion of total dust, according to the international ACGIH/ISO/CEN/NIOSH respirable convention. The respirable dust collected by virtual cyclone meet 94.6 percent dust weight of our estimation from the respirable curve, while the nylon cyclone only meets 79.3 percent of the estimation, which is likely due to aerosol loading effect.

New virtual cyclone was tested and proved as a precise and accurate respirable dust sampler, matching perfectly with the respirable sampling convention. Nylon cyclone and other commercial cyclones suffered from loading effect and underestimate the dust concentration in working place. It is recommended that size-selective devices, such as virtual cyclone, be used for aerosol exposure assessment in the workplace and ambient environment.

Experimental measurement of charge on aerosol particles

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Abstract:

Previous studies about haze formation mainly focused on various chemical components in aerosol particles and their physical-chemical effect on particle behaviours (eg., generation, growth, agglomeration). This paper describes the measurement of the charging state on aerosol particles, by considering the non-uniform distribution of free ions on aerosol particles, that could be caused by size difference and temperature differences between particles. The experimental setup was established on Dec. 2017 and experiments were carried out on the roof of the west 4th building on the Qujiang Campus at Xi'an Jiaotong University. The measurement position was at approximately 20m above the ground level. Our results showed that most of atmospheric particles would carry negative or positive charges. The number of elementary charges of atmospheric particles was more than one. The average charge amount on particles was higher during winter than during summer. The number concentration of charged particles was higher during daytime than during nighttime. Besides, a strong relationship between the mass concentration of PM_{2.5} and the charge amount on particles was observed. These experiments implied that the particle formation could partly be attributed to the variation of particles' charging state, which might be related to meteorological conditions.

Piecewise Log-Normal Distribution for Representing the Size Distribution of Aerosol Particles

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Abstract:

Particle size distributions strongly affect the physical properties of aerosols, such as light scattering, toxicity, static charging, migration and deposition. Among different dynamic processes, coagulation plays an important role in determining the particle size distribution. The time evolution of the size distribution due to coagulation is one of the key topics in aerosol dynamics, which is governed by the population balance equation (PBE). The log-normal method of moments (LNMOM) has been widely used to simulate the size distribution evolution regarding its both accuracy and efficiency. However, the actual size distribution may not be symmetric in log scale. Especially for Brownian coagulation, previous studies have shown that the self-preserving size distribution is negatively skewed in log plots. The skewness characteristic cannot be well described by the conventional LNMOM, so we use a piecewise log-normal distribution to better represent the size distribution. This modified distribution can be positively skewed or negatively skewed based on the distribution parameters. In addition, the piecewise log-normal distribution can be easily constructed from moments. Then we validate the new method for Brownian coagulation in the continuum regime and the free-molecular regime. The simulation results show that the piecewise log-normal distribution is much closer to the actual size distribution than the log-normal distribution during entire coagulation time. Moreover, the new method has better accuracy than the LNMOM in predicting the size distribution parameters including the particle number concentration and the geometric standard deviation.

What modern theory can say on the nonstationary formation and growth of submicron multicomponent aerosol droplets on nucleation stage?

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Abstract:

Nucleation and growth of aerosol droplets pass through several stages. First critical droplets appear on the incubation stage. The next is the nucleation stage, on which new critical droplets continuously upspring, while supercritical droplets formed earlier increase in size. Small decrease in the vapor supersaturation on this stage stops appearance of new supercritical droplets, and the formed distribution of droplets in sizes can serve as a milestone.

In past, a great contribution to the theory of multicomponent nucleation has been done with respect to finding the composition of critical droplet, nucleation rate and nucleation path. A general kinetic approach to the incubation stage had been constructed with the use of method of complete separation of kinetically stable and unstable variables. In particular, an analytical solution of time dependent deliquescence on the incubation stage had been found [1].

The traditional mean-field approach to the kinetics of the nucleation stage is based on assumption that nucleation proceeds with synchronous and uniform over the volume decrease of the vapor supersaturation. The rate of formation of new supercritical droplets is reduced over the whole system simultaneously with the vapor supersaturation. The mean-field approximation implies that diffusion of vapor molecules to droplets is stationary. To explain the influence of the local vapor nonuniformity arising due to nonstationary diffusion to supercritical droplets, we used the idea of the excluded volume in the nucleation process [2] and self-similar solution of the spherical diffusion problem. The approach with excluded volume for isothermal and nonisothermal conditions [3] takes into account that, in a non-uniform diffusion shell surrounding a supercritical droplet, nucleation of new droplets is suppressed due to small vapor supersaturation in this shell, while outside the shell, the intensity of nucleation remains at the initial level. It has been shown that the vapor diffusion to droplets can be close to the stationary process because of the strong differences in densities of the vapor and liquid, but under nonisothermal conditions can be responsible for the cloud thermal expansion [4].

In this report, we apply the theory for the nucleation stage of gas bubbles formation at degassing of a multicomponent solution [5] to the nucleation stage of multicomponent nucleation and growth of supercritical droplets. A procedure allowing finding the time dependences of all vapor supersaturations

and the distribution of supercritical droplets in sizes on the nucleation stage, will be presented below and illustrated in the case of ideal multicomponent solution in supercritical droplets [6,7].

This work was supported by Russian Foundation for Basic Research.

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Multidimensional characterization of non-spherical nanoparticles

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Abstract:

Multidimensional characterization of nanoparticles is quite relevant and important as in addition to size, particle shape and structure also plays a vital role in altering the final product properties. Non-spherical nanoparticles are quite ubiquitous, and shape plays a major role in the excellent product properties of these nanoparticles. Scanning mobility particle sizer (SMPS), one of the most commonly used characterization techniques, classifies particles based on their electrical mobility which depends on the charge of the particles and their scalar friction factor. There have been recent advances made in accurately relating the electrical mobility of non-spherical nanoparticles to their geometrical parameters. Recent experimental and computational studies have shown that precise mobility calculations can be made with the knowledge of two geometrical parameters, namely the hydrodynamic diameter and the orientationally averaged projected area. The mobility of particles, which is related to the inverse of the friction factor is measured in SMPS and have implicit information of hydrodynamic diameter and orientationally averaged projected area for non-spherical nano aerosol particles. It will be shown how the mobility measurements can be combined with an orthogonal measurement technique to measure the length and diameter of nanorods in a sample. Sedimentation analysis can be used in combination with mobility analysis for multidimensional characterization of non-spherical nanoparticles.

For fractal aggregates, images from microscopy techniques is the most popular method to study the morphological aspects. For complete geometrical information, three dimensional structures should be recreated from the two dimensional images. Optimization techniques need to be employed to obtain the representative three dimensional structures using image analysis. Machine learning can provide new dimension to the optimization algorithms and are used for more accurate image analysis.

Atmospheric Aerosols in Indian Perspective: Climate and Ecosystem Health Implications

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Abstract:

The unprecedented industrial and urban growth is always associated with emission of various pollutants including aerosol particles (fine suspended particles in the atmosphere either solid or aqueous) and harmful gases. The atmospheric aerosol particles interact with the incoming solar radiation “directly” altering the Earth’s radiation budget (in a sense temperature) and are important and necessary elements in the process of cloud formation. The changes in lifetime, type, properties, and characteristics of cloud due to increasing aerosol concentration, in turn, “indirectly” affects the Earth’s radiation budget. In addition, clouds are responsible for all type of precipitation on the Earth and therefore aerosol are important elements in governing the hydrological cycle on the Earth. Thus, the changing aerosol properties can perturb the cloud properties including lifetime and hydrological cycle of the planet. Based on the ice core data while we are accurately able to determine the pre-industrial era (year 1750) concentration of greenhouse gases, which are responsible for warming of the Earth surface we have no means to determine the historical cloud cover of the Earth or how it has changed, if at all, over last three centuries? Therefore, aerosol – cloud – climate interaction represents the largest uncertainty in current and future understanding of climate change and scientists are not able to give the precise estimate about how much temperature rise is expected at the end of this century. More to this, of late the research has also started focusing the role of aerosols of biological origin (bacteria, fungal spore, pollen grains, plant and animal fragments, etc.) on cloud formation and ecosystem health impact.

Indian climate system and ecosystem are very different and unique compared to rest of the world. While the former is characterized by the systematic and cyclic monsoon season and associated south westerly prevailing winds the latter is marked by the presence of fragile and sensitive ecosystems like Indian Himalayan range and Western Ghats. Since last couple of decades, India has also experienced the tremendous industrial and urban growth and has been exerting regional and global climate impact. During my presentation I will briefly touch the aspect related to studies we are carrying out about understanding the role of aerosols (including bioaerosols) and trace gases on Indian climate and ecosystem health. I will, in particular, elaborate about our current understanding about the role of changing aerosol properties over India in cloud and precipitation formation processes on regional to local scale.

High-resolution analysis of organic aerosols in the atmosphere of Hong Kong with the application of TAG-GC-ToF-MS

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Abstract:

This is the first study on the real-time measurements of organic aerosols at a roadside site and at an urban site in Hong Kong with the aid of a Thermal-desorption Aerosol Gas Chromatography-Time of Flight – Mass Spectrometer (TAG-GC-ToF-MS). High-resolution measurements of hourly C₁₃-C₄₀ n-alkanes and PAH species in particle- and gas-phase were carried out in winter 2017 near the Cross-Harbor Tunnel, while POA and SOA tracers were monitored in autumn 2018 at the roof-top of a PolyU building in Hong Kong. The results indicated that n-alkanes dominated over PAHs in PM_{2.5}, with the average concentrations of 87.3±4.6 and 5.9±0.3 ng/m³ on weekdays, and 70.1±5.6 and 4.9±0.6 ng/m³ on weekends, respectively. At the roadside site, while PAHs showed typical bimodal pattern in daily cycle, n-alkanes only peaked at noon. Insight into the diurnal patterns of individual n-alkanes found that the large molecular (C₂₁-C₃₃) n-alkanes had both the morning and evening peaks, in contrast to the single peak of C₁₃-C₂₀ n-alkanes at noon. Both CPI and Wax index implied that n-alkanes were almost exclusively derived from vehicle exhausts, except for one case when wax accounted for >20% of n-alkanes and many water-soluble substances (e.g. lauric acid, tetraethylene glycol and triethylene glycol) were detected with high abundances. PMF source apportionment analysis resolved two factors with one characterized by fluoranthene, pyrene, NO and NO₂, and the other one containing more chrysene, benzo[a]pyrene and CO. The results revealed that gasoline exhaust was the source of larger molecular n-alkanes (>C₂₁) and PAHs, and made higher contribution (13.9±1.3 µg/m³) to the total organics in PM_{1.0} than diesel exhaust (6.0±0.4 µg/m³) which was responsible for the emissions of C₁₃-C₂₀ n-alkanes. In the afternoon of a Sunday, the PM_{1.0}-bound total organics were even elevated by ~55 µg/m³ by gasoline exhaust. On the other hand, SOA tracers of biogenic VOCs were often detected at the urban site with a peak at noon. The findings advance our understandings on emission characteristics of POA and formation mechanisms of SOA.

Keyword: TAG-GC-ToF-MS; n-Alkanes; PAHs; SOA; Roadside and urban sites

Acknowledgement: This project was supported by the Research Grants Council of the Hong Kong Special Administrative Region (C5004-15E) and the Strategic Focus Area Scheme of the Research Institute for Sustainable Urban Development at the Hong Kong Polytechnic University (1-BBW9).

The effect of AS on the heterogeneous OH oxidation of methylglutaric acid: Kinetics and chemistry

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Abstract:

Atmospheric aerosols, consisting of inorganic salts, organic compounds and a varying amount of water, can continuously undergo heterogeneous oxidation initiated by gas-phase oxidants, changing the composition and properties of the aerosols over time. To date, most studies focus on the chemical evolution of pure organic aerosols upon oxidation. To gain fundamental insights into the effects of inorganic salts on the heterogeneous reactivity of organic compounds, we investigate the heterogeneous OH reactions of 3-methylglutaric acid (3-MGA) aerosols and aerosols containing 3-MGA and AS at an organic-to-inorganic mass ratio of 2 in an aerosol flow tube reactor at a high relative humidity of 85 %. The molecular information of the aerosols before and after OH oxidation is obtained using the DART, a soft atmospheric pressure ionization source, coupled to a high-resolution mass spectrometer. We found that both 3-MGA and 3-MGA/AS aerosols are homogeneously well-mixed prior to oxidation at high humidity. Aerosol speciation data show the same major reaction products formed upon oxidation regardless of the presence of AS, suggesting that the salt does not significantly affect the reaction pathways. The dominance of alcohol functionalization products over carbonyl functionalization products is observed. This could be explained by the intermolecular hydrogen abstraction by tertiary alkoxy radicals formed at the methyl-substituted carbon site. Kinetic measurements show that the effective OH uptake coefficient, γ_{eff} , for 3-MGA/AS aerosols (0.99 ± 0.05) is smaller than that for 3-MGA aerosols (2.41 ± 0.13) by about a factor of 2.4. A smaller reactivity observed in 3-MGA/AS aerosols might be attributed to a higher surface concentration of water molecules, and the presence of ammonium and sulfate ions, which are chemically inert to OH radicals, near the aerosol surface. This lowers the reactive collision probability between the 3-MGA and OH radicals, resulting in a smaller overall reaction rate. Our results suggest that inorganic salt appears to lower the overall heterogeneous OH reactivity of the organic compounds in well-mixed inorganic/organic aerosols.

A comparison of aerosol chemical composition under several different environments in China

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Abstract:

Atmospheric aerosols play an important role in haze formation in China and in climate globally. Here we present an observational comparison of chemical composition of non-refractory PM₁ under several distinct atmospheric environments in China: urban atmosphere in Guangzhou (December-January), two mountain-top atmospheres in Wudang Mountain in central China (May-June) and in Tianjing Mountain in Guangdong, and atmosphere over China Southern Sea (CSS, August). An online Time of Flight Atmospheric Chemical Speciation Monitor (ToF-ACSM) was deployed to measure sulfate, nitrate, ammonium, chlorine, and organic composition of atmospheric aerosols. The preliminary results show a surprisingly high aerosol loading at the mountain site (as high as above 30 microgram per cubic meter), dominated by organics (about 50%), followed by sulfate (about 30%) and ammonium (10%). Significant differences of aerosol chemical composition prior to and after typhoon Beibijia were seen and in general comparable amounts of sulfate and organics were observed in the atmosphere over CSS. The composition over this area was mostly contributed from ship emissions and pollution transport from nearby land emissions. Chemical composition during the measurement period in urban Guangzhou was dominated by organics (about half) and a significant amount of nitrates was also observed during this period. An insignificant amount of chlorine (about 1-2%) was found under all the four atmospheric environments. Source apportionment and atmospheric implications are also discussed.

Keywords: chemic composition, air pollution, atmospheric observation, atmospheric aerosols, ToF-ACSM

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Effect of relative humidity on light-absorbing secondary organic aerosol formation in the evaporating droplets

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Abstract:

Uptake of water-soluble volatile organic compounds (VOCs) into aerosol, fog and cloud droplets can lead to the formation of aqueous-phase secondary organic aerosols (aqSOA). Glyoxal (GL) and Methylglyoxal (MG), two α -dicarbonyls formed through oxidation of various biogenic and anthropogenic VOCs, are model aqSOA precursors due to their atmospheric abundance and high solubility. Many previous studies have shown that reactions of both GL and MG with inorganic and organic nitrogen-containing compounds can produce light absorbing organic aerosol (OA) in bulk solutions on the order of hours/days. Such reactions can be accelerated upon droplet evaporation under dry condition (e.g., RH < 30%), where light absorbing OA are formed on the order of seconds. However, despite aerosol particles being exposed to a wide range of RH throughout their atmospheric lifetime, the behaviour of light absorbing OA formation in response to the surrounding RH conditions is not well understood.

This study aims to investigate the formation of light absorbing aqSOA in evaporating droplets and to quantify their absorption properties as a function of RH. Mass absorption coefficient (MAC, m^2/gC) of light absorbing OA produced through reactions of GL and MG with ammonium sulfate (AS) or glycine (Gly) in evaporated droplets were investigated. Bulk solutions with atmospherically relevant concentrations of reactants were atomised and the aqueous droplets were subsequently conditioned between 30% and 85% RH to facilitate droplet evaporation. The variations of MAC with RH at different peak wavelengths were similar for all systems: started with low MAC in bulk solution, steadily increased from ~85% RH, peaked at ~55-65% RH, and declined towards lower RH (~30%). The initial increase of MAC values are attributed to the acceleration of reactions promoted by the highly concentrated solute environment in the evaporating droplets. However, further drying may lead to significant evaporative loss of both reactants and products and reduced mobility of molecules for undergoing aqueous reactions, resulting in the decreasing trends of MAC at lower RH conditions. In particular, the reaction systems with Gly showed significantly low MAC values at RH < 30%, which are comparable to those observed in the bulk solutions. Overall, our results show that the light absorbing OA formation upon droplet evaporation of the model aqSOA systems varies substantially with the surrounding RH, providing new insight into the brown carbon formation chemistry via aqueous processing and related model development.

Nitrate enhances near-UV/visible absorption of brown carbon (BrC) model compounds during aqueous-phase photolysis

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Abstract:

Brown carbon (BrC) in atmospheric particles has strong impacts on the radiative budget, thus on climate (1,2). BrC can also evolve during their suspension in the atmosphere, for example, by photochemical reactions (3). Previous studies have investigated gas-phase (4) or aqueous-phase (5) reactions of BrC. Some reactions break down the chromophores, while others build up larger conjugated systems and extend the absorption into the visible range. The effects of photo-active species other than commonly used H₂O₂, such as nitrate that also photolyzes to generate radicals, have seldom been investigated. Herein, we report experimental results of aqueous-phase photochemical reactions for four commonly found BrC model compounds, including 4-nitrocatechol (4NC), 3-nitrophenol (3NP), vanillin (VL), and vanillic acid (VA), in the absence or presence of nitrate. Results show that for 254-nm illumination, the decay of the BrC model compounds was evident in all conditions, but the changes in the spectra were different in conditions tested. For direct photolysis (UV only), all model compounds showed decreases of absorbance in the UV range, and slight increases in the visible range. For UV + H₂O₂, all model compounds showed substantial decreases in both UV and visible ranges, indicating efficient photo-bleaching with OH radicals generated. For UV + NaNO₃, the decreases in the UV range were less significant, while the increases in the near-UV/visible range were the strongest, indicating formation of larger chromophores, probably introducing nitro groups, as revealed by mass spectrometric analysis. The results show that the presence of nitrate during BrC photolysis can form new chromophores that extend their absorption to visible range and contribute to atmospheric energy balance.

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Electrospray-Surface Enhanced Raman Spectroscopy (ES-SERS) for Studying Organic Coating in Atmospheric Aerosol Particles

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Abstract:

Heterogeneous reactions between atmospheric aerosol particles and gaseous pollutants are one of the important mechanisms in altering the chemical compositions and aerosol-climate interactions, such as the formation of brown carbon (BrC). While most studies assume homogeneous compositions in the particles, the formation of organic coatings due to reactions on solid or highly viscous particles is possible but relatively less examined. We used electrospray surface-enhanced Raman spectroscopy (ES-SERS) to directly probe the formation of BrC coatings on methylammonium (MeA) sulfate, nitrate, and chloride particles by heterogeneous reactions of gas phase glyoxal, which can produce 1,3-dimethylimidazole as one of the major products. To retain the BrC coating on the surfaces, the heterogeneous reactions were performed under low relative humidity (RH) conditions (10 or 30% RH). The reacted particles show fluorescence when the particles were irradiated at 532 nm in normal Raman analysis, indirectly suggesting the presence of light-absorbing species in the particles. ES-SERS analyses exhibit Raman bands of 1,3-dimethylimidazole from all the reacted particles at 30% RH. However, only MeA sulfate particles show the formation of BrC coating at 10%RH. It is speculated that MeA sulfate particles may form more SAW than other particles to initiate the formation of BrC. The present study highlights the surface sensitive detection by ES-SERS as well as the importance of SAW in heterogeneous reactions.

Low-cost Sensors: Calibration and New Algorithms

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Abstract:

Compact low-cost sensors for measuring particulate matter (PM) concentrations are receiving significant attention as they can be used in larger numbers and in a distributed manner. Wang et al. (2015)¹ compared three types of popular low-cost PM sensor from Sharp, Shenyei, and Samyoung and summarized advantages and disadvantages of each sensor. To ensure accurate and reliable representation of PM mass concentrations, we calibrated the Sharp sensor with an optical method to study signal's dependence on composition and size distribution. The results indicate that repeated calibration is needed for low-cost sensors². In addition to laboratory studies, a networked low-cost PM sensor system was applied in field measurements. They were deployed in households in Raipur, India to establish the spatiotemporal variation of PM concentrations³. From another study, in a woodworking shop, data collected by the networked sensor system was utilized to construct spatiotemporal PM concentration distributions using an ordinary Kriging method and an Artificial Neural Network model to elucidate particle generation and ventilation processes⁴.

The performance of nine types of commercial low-cost monitors were compared, including a new design of a wearable sensor, APT Minima. These low-cost monitors were calibrated before distribution to users. We demonstrated that the conventional calibration method may bias the performance of the monitors whose major component is an optical particle counter. Coincidence error will lead to an inaccurate size distribution but has little influence on the mass concentration prediction. For some low-cost monitors with color display for residential use, we also tested whether they could trigger an alarm on time by testing with sodium chloride, incense, and Arizona road dust particles. In our previous experiments, low-cost PM sensors or calibrated low-cost PM monitors all demonstrated a dependence on the PM composition and the size distribution. To overcome such dependence, we propose a new data inversion algorithm that can maximally reduce the dependence caused by refractive index, especially for optical particle counters. A LED light source and a Hamamatsu spectrometer were equipped with an existing optical particle counter to test the data inversion algorithm.

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Microsensor Comparison and Evaluation for Determining and Managing Area Source Emissions

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Abstract:

Air quality microsensor components are based on: 1) multiwavelength radiation absorption, scattering, diffraction, and colorimetry; 2) electrochemical reactions; 3) metal oxide semiconductors; 4) surface plasmon resonance; and 5) microfluidics. Several hundred published articles and reports outline concepts and methods for these sensors with numerous comparisons to compliance monitors. Nearly all particulate matter (PM) microsensors use light scattering, usually from an inexpensive 650 nm diode laser, which is related to PM concentrations by unknown methods. The Plantower 5003 and 7003 sensors report PM₁, PM_{2.5}, and PM₁₀ mass concentrations along with number counts in five size ranges. Disassembly of the Plantowers demonstrates that they cannot count individual particles and that large particles deposit in the tortuous path to the sensing volume. Nevertheless, these sensors have utility for real-time PM detection that can be used for reducing emissions, especially around area sources.

Dual 5003 sensors have been packaged by PurpleAir with data acquisition and a WiFi interface for real-time detection. These are collocated with WiFi connected meteorological stations around a solid waste clean-up site to determine the potential for off-site transport. A simple Python program periodically downloads and unifies the PM and meteorological data from the cloud-based websites and applies decision criteria that is relayed to the site manager as a text message. With this information, changes in the excavation and earthmoving operations can be made to minimize the off-site effects.

Similarly, PM and temperature microsensors are located at different elevations on buildings and elevated terrain in a mountain valley to determine conditions under which the surface inversion couples to layers aloft, thereby changing the breathing zone exposures. These data are used to refine and implement forecasts that dictate emission reduction actions, such as curtailing residential wood combustion.

Improvements in currently available PM light scattering systems would include: 1) multiple wavelength scattering to better estimate particle size and composition; 2) scattering detection at multiple angles,

which would also enhance classification by size and composition; 3) simultaneous measurement of scattering and transmittance to estimate light absorption, preferably and multiple wavelengths; and 4) a more direct path to the sensing zone to better quantify large particles from fugitive dust emissions.

Community Source Identification and Exposure-Health Evaluation with Low-Cost PM2.5 Sensors

Shih-Chun Candice Lung

Academia Sinica

Wen-Cheng Wang, Academia Sinica

Chun-Hu Liu, Academia Sinica

Julia Z.Y. Wen, Academia Sinica

Joanne S.C. Hu, Academia Sinica

Abstract:

Sensors devices, called AS-LUNG, short for Academia Sinica-lung (the organ affected by air pollutants) of outdoor, indoor, and personal versions were built for fixed location monitoring, indoor air quality evaluation, and personal exposure assessment, respectively. They were compared with sophisticated instruments for correction in the laboratory and in the field. They were also deployed in Taiwanese communities along with health sensors to assess PM2.5 exposure-health relationships in fine temporal resolutions and to identify community sources.

AS-LUNG integrates low-cost sensors of PM2.5 (Plantower PMS3003), temperature, relative humidity, GPS, and 3-dimensional motion detection. The outdoor version is connected with a solar panel while the portable one is connected to a mobile battery. The outdoor, indoor, and portable versions all have WIFI and SD cards for data transmission and storage. About 70 sets of the outdoor version have been installed in the communities while about 30 sets of the indoor version were put inside subjects' houses for indoor air quality assessment. In addition, 28 subjects aged 40-75 carried the portable sensors for 7 days to assess their exposure levels and exposure-health relationship in September-October 2018.

The evaluation results demonstrated that the readings of AS-LUNG, with good precisions, can be corrected by the co-location comparison results with GRIMM instruments. The outdoor sensor devices were able to quantify PM2.5 increments from local community sources, providing scientific evidences for further control and regulatory strategy settings. Furthermore, the lightweight portable PM2.5 sensors provided fine resolution exposure levels for exposure-health relationship evaluations. The pros and cons of applying low-cost sensors in community monitoring, indoor air quality assessment, and personal exposure assessment will be presented.

Keywords, PM2.5, low-cost sensors, exposure assessment, health oriented study

Test Method for a Low Cost Dust Sensor with Dynamically Changing Particle Concentration

Kang-Ho Ahn

Hanyang University

W. Y. Kim, Hanyang University

H. Chung, ART+

K. Kang, ART+

Abstract:

- Why do we need a new test method for the low cost dust sensors?

The low cost dust sensors have widely been used recently for the detection of atmospheric particles. Air purifiers, air conditioners, handheld PM sensors for citizen scientists, and IoT applications are the most common application areas for the low-cost dust sensors. The operating principle of these sensors is based on the light scattering of particles either by a LED or a Laser light. However, the measurement accuracy of the sensors has always been questioned by many users. Two types of test methods are known for the evaluation of the sensors, i.e., a chamber method and a continuously flowing low speed wind tunnel method with several different types of test particles. A cigarette smoke, Arizona Road Dust, KCl, and many other types of materials have been used for the sensor performance evaluation. In this test method, KCl has been used not only because of the easiness of the size distribution control, but also the easiness of handling. The density and the purity of the KCl are also well defined.

- Experimental method

KCl solution is sprayed in order to generate droplets, and then mixed with clean dry air to evaporate droplets. This process will make solid KCl particles. The static charge of the particles will be neutralized by a soft X-ray. These particles are diluted with clean dry air again. And then particles are introduced into the test duct. The cross section of the test duct is a regular quadrilateral. The flow velocity at the test section in the duct should be 0.1 ± 0.05 m/s at all five measurement points. The flow velocity measurement points are the centers of the each quadrant of the cross-section of the test duct. In addition, the particle concentration uniformity in the test duct at the five sampling points should not exceed $\pm 15\%$ of the mean value of the five measurement points. The five flow uniformity measurement points are identical to the five particle sampling points. Three test specimens are placed in the test duct with a research grade reference particle counter sampling probe that is inserted into the test duct. And then KCl particle concentration is exponentially decreased as a function of time in the test duct. The low cost dust sensor readings and the reference particle counter data are plotted on a semi-log graph as a function of time. From this test results one can easily figure out not only the dynamic performance of the low cost sensors but also the accuracy of the sensors with very short sensor evaluation time. The

sensor test time usually takes less than 10 minutes. More detailed test procedure and some of the test results will be presented at the conference.

City Wide Mobile Air Sensor Network (MASEN) In Hong Kong For Evidence Based Air Quality Management

Zhi Ning

Division of Environment and Sustainability, The Hong Kong University of Science and Technology

Fenhuan Yang, School of Energy and Environment, City University of Hong Kong

Abstract:

In urban areas, vehicles emissions are a major source of air pollution (HEI, 2010), especially particulate matter (PM) and nitrogen oxides (NO_x). This study presents the recent work in Hong Kong using mobile air sensors on buses to form a large scale sensor network with continuous measurements of PM_{2.5}, NO, NO₂, CO and CO₂ pollutants along more than 40 bus routes. We have found high heterogeneity of the pollutants concentrations in more complex urban terrain with its complexity in built environment, which poses an increasing challenge to accurately quantify and assess trend of air pollution for science based evidence collection for policy making. The mobile sensor network data also showed interesting effect of combined impact of local and regional pollutions. This also leads to increasing consideration and discussions for a new monitoring paradigm shift from static ambient monitoring to spatio-temporally resolved higher density monitoring network. Recent technological advances in air monitoring allow unprecedented opportunities for such air monitoring network using low cost and high quality sensors, which require less infrastructure support than the traditional stationary monitoring stations. New sensing techniques in dense and complex urban environments can be operated at a fraction of the cost of conventional devices and produces unprecedented "big data" in high temporal and spatial resolution. Such mobile network would also have high potential to supplement the existing regulatory air monitoring networks, and provide evidence of association between the roadway network traffic and the air quality in different urban areas.

KEYWORDS: Mobile sensor network, traffic emissions, roadway network, air quality management, smart city

REFERENCE:

HEI (Health Effects Institute) (2010) Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. HEI Special Report 17, Health Effects Institute, Boston, MA, pp. 2-3, 3-3, 3-27.

Yuan, Z., Yadav, V., Turner, J.R., Louie, P.K.K., Lau, A.K.H. (2013) Long-term trends of ambient particulate matter emission source contributions and the accountability of control strategies in Hong Kong over 1998-2008. *Atmos. Environ.* 76 (0), 21-31.

ACKNOWLEDGMENT:

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Number Counting of Persons in a Focused Environment using a Portable Sensor detecting Wi-Fi Packet Signals from Mobile Phones

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Quian Chen, Kanazawa University, Japan

Abstract:

The total risk or influence from the environmental pollution should take into account the number of persons who may be affected by the pollution. As a counting tool, a battery driven portable sensor, which can detect a Wi-Fi packet signal emitted from a specified mobile phone, was investigated through the field measurement on the detectable intensity and number of signals in relation to a distance between Wi-Fi packet sensor (WPS) and a mobile phone, influences of type of phones and OS, installation height of WPS, side of a mobile phone to WPS. The tested WPS was then applied to an outdoor smoking booth, where the number of smokers was counted both by WPS and visual observation to discuss the correlation. The WP signal could be detected up to ~ 100 m and its detection was affected by the side of a mobile phone to WPS, or, the front side provided a better detection of signal. The signal detection was also influenced by the height of installation of WPS, where the installation on the ground provided less detectable distance but more selective signal detection in a distance less than ~30 m. There was a clear correlation between the number counted by WPS and visual observation although various affecting parameters should be discussed further.

Low-Cost Air Quality Sensor Node Application to Pollution Management Systems in Chinese Cities

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Chunying Wang, Hebei Sailhero Environmental Protection Hi-tech., Ltd

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Yi Li, Sunset CES Inc.

Varuu Yadav, Sunset CES Inc.

John Cooper, Sunset CES Inc.

Abstract:

In recent years, low-cost air sensors designed to measure ambient particulate matters and trace gases have been changing the world of air quality monitoring. A wide number of sensor nodes have been used for community air quality monitoring, pollution hot spots screening, and transportation emission management, etc.

In order to design a robust sensor node, a four-step screening/calibration system was established using a simulated environmental chamber and machine learning algorithms. Sensors set up in a network following Internet of Things (IoT) design principles have been used by local environmental agencies to track down air pollution. Since 2015, over 10000 sensor nodes have been installed in 120 Chinese cities and districts, with some cities exceeding 1000 sensors in their networks. The machine learning and IoT based network make sure each sensor is automatically calibrated and keeps providing certified data to be used for governmental decision making. The whole sensor system GMS (Grid Monitoring System) has played an important role in sudden pollution problem, location of pollution source, and environmental management decision support.

Firstly, compared with the traditional air quality monitoring station, GMS has the advantage of high-temporal- spatial-resolution. When sudden uncertain air pollution case occurs, sensors nearby would give warning signals in minutes and send to government sector, who could take measures immediately.

Secondly, for unknown pollution sources, sensors always send out a warning signal in the downwind direction when polluted gas emit, and the affected sensors change with different wind direction. The location of the pollution sources would be locked through the cumulative analysis of different wind

conditions. GMS has been used on unknown pollution source identification, which provided effective support for pollution prevention and control management work.

Thirdly, combination analysis with other monitoring data (Source apportionment), GMS provides more valuable decision support in environmental management. And benefited from its low cost and small size, sensors can be applied in many fields, for example, economic, medical, health besides the environmental monitoring.

The network has already played a significant role in successfully aiding the government in conducting effective environmental pollution control. In Fuyang city, Anhui Province, the annual Air Quality Composite Index (AQCI) has decreased from 6.427 in 2017 to 4.712 in 2018 with the annual PM_{2.5} concentration decreasing from 77 ug/m³ to 51 ug/m³. Xinxiang, Henan province is another example, with the annual AQI and PM_{2.5} concentrations showing considerable decreases by 12.4% and 21.43%, respectively.

Due to their inherent advantages over conventional methods by being low-cost, portable, and by having high spatial coverage, air sensor technology will continue to expand in China. Meanwhile, as market regulator, government will need to establish standards and processes for air sensor evaluation and certification.

Parallel Oral Session IV

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

29 May 2019 (Wednesday) | 10:30 – 12:00

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Special symposium: Aerosol-water interaction (1) Co-chair(s) 1. Mingjin Tang, Chinese Academy of Sciences 2. Yutaka Tobo, National Institute of Polar Research	Mingjin Tang, Chinese Academy of Sciences	Water adsorption and hygroscopic growth of six anemophilous pollen species: the effect of temperature	10:30-10:45	Chan Kei Biu Lecture Theatre (LT-6)
	Jing Chen, Nanyang Technological University	Highly polar water-soluble organic matter dominates the hygroscopic growth of Indonesian biomass burning particles	10:45-11:00	
	Jingyi Li, Nanjing University of Information Science and Technology	Impacts of water partitioning and polarity of organic compounds on secondary organic aerosols over Eastern China	11:00-11:15	
	Haichao Wang, Peking University	Evaluating dominant factors control N2O5 uptake: a case study in polluted winter in North China Plain	11:15-11:30	
	Yang Chen, Chinese Academy of Sciences	High relative humidity enhances the particulate diethylamine in an urban area	11:30-11:45	
	Yutaka Tobo, National Institute of Polar Research	Routine measurements of atmospheric ice nucleating particles on Tokyo Skytree: Preliminary results in 2016/2017	11:45-12:00	
Special symposium: Sulfur aerosol chemistry (2) Co-chair(s) 1. Masao Gen, City University of Hong Kong 2. Zhe Wang, The Hong Kong Polytechnic University	Zhongming Chen, Peking University (<i>KC Wong Foundation Invited Speaker</i>)	How do peroxides promote the formation of atmospheric particles?	10:30-11:00	SAE Magnetics Lecture Theatre (LT-9)
	Hon Yin Poon, The Chinese University of Hong Kong	The yield of inorganic sulfate ion from heterogeneous OH oxidation of organosulfates	11:00-11:15	
	Yuzhi Chen, The University of North Carolina at Chapel Hill	Extensive Isoprene Epoxydiols Conversion of Inorganic to Organic Sulfur Alters Aerosol Properties	11:15-11:30	
	Yuchen Wang, Hong Kong University of Science and Technology	Abundance of Organosulfates in China: Seasonal and Spatial Contrasts	11:30-11:45	
	Kai Wang, Aarhus University	The effect of temperature, humidity and seed aerosol acidity on secondary organic aerosol (SOA) from the photo-oxidation of isoprene	11:45-12:00	
Special symposium: Atmospheric aging (2) Co-chair(s) 1. Anthony Wexler, UC Davis 2. Ralf Zimmermann, Rostock University & Helmholtz Zentrum München	Ralf Zimmermann, Rostock University & Helmholtz Zentrum München	Fresh and aged combustion aerosols: Chemical composition and molecular biological/toxicological effects on air-liquid-interface exposed human lung cells	10:30-10:45	Peter Ho Lecture Theatre (LT-10)
	Pasi Jalava, University of Eastern Finland	Atmospheric aging affects the toxicity of the emissions from wood and lignite combustion	10:45-11:00	
	Lu Lu, National University of Singapore	Effects of oxidative processing on particle-bound reactive oxygen species formation from incense burning and cooking fumes	11:00-11:15	
	Hendryk Czech, University of Rostock	Implications of photochemical ageing for source apportionment and health effects of wood combustion aerosol	11:15-11:30	
	Anthony Wexler, UC Davis	Detection of toxic metals in the atmosphere: Development of a low-cost spark-induced breakdown spectroscopy (SIBS) system	11:30-11:45	
	Ling Jin, The Hong Kong Polytechnic University	Differential toxicities and contributing components in urban PM2.5	11:45-12:00	
Remote sensing (1) Co-chair(s) 1. Sheng-Hsiang Wang, National Central University 2. To be confirmed	Sheng-Hsiang Wang, National Central University (<i>Invited Speaker</i>)	Long-term study of aerosol extinction-to-backscatter ratio with combination of micro-pulse LIDAR and AERONET over northern Taiwan	10:30-11:00	Jennifer and Haywood Cheung Lecture Theatre (LT-13)
	Tianze Sun, Chinese Academy of Meteorological Sciences	Characterization of vertical distribution and radiative forcing of ambient aerosol over the Yangtze River Delta during 2013–2015	11:00-11:15	
	Lei Li, Chinese Academy of Meteorological Sciences	Temporal and spatial characteristics of aerosol chemical composition retrieved from POLDER/PARASOL observations over Asia from 2005 to 2013	11:15-11:30	
	Wonei Choi, Pukyong National University	Aerosol height retrieval using space-borne Vis hyperspectral sensor based on O4 absorption: New applications of spatiotemporal O4 Column Densities and Temperature-Dependent O4 Absorption Cross Section	11:30-11:45	
Aerosol-climate-meteorology (1) Co-chair(s) 1. Stephen M. Griffith, Dept. of Atmospheric Sciences, National Central University	Stephen M. Griffith, National Central University	Probing aerosol acidity at three sites during a 2015 intensive observation period in Taiwan	10:30-10:45	Leung Ko Yuk Tak Lecture Theatre (LT-14)
	Weijun Li, Zhejiang University	Cloud scavenging of anthropogenic refractory particles at a mountain site in North China	10:45-11:00	
	Hua Zhang, Chinese Academy of Meteorological Sciences	The Change of Anthropogenic PM2.5 since 1850 and its Global Climate Effects	11:00-11:15	
	Weizhao Xu, Peking University	Diesel Black carbon aging under urban atmosphere using a QUasi-atmospheric Aerosol evolution study (QUALITY) chamber	11:15-11:30	

2. Meng Gao, Harvard University	Jie Tang, China Meteorological Administration	The trend of black carbon concentration at 3 background monitoring stations of China, from 1990s to 2017	11:30-11:45	
	Yim, Hung-Lam Steve, The Chinese University of Hong Kong	The impact of the aerosol direct radiative forcing on deep convection and air quality in the Pearl River Delta region	11:45-12:00	

Water adsorption and hygroscopic growth of six anemophilous pollen species: the effect of temperature

Mingjin Tang

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Wenjun Gu, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Qingxin Ma, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences

Yong Jie Li, University of Macau

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Ru-Jin Huang, Institute of Earth and Environment, Chinese Academy of Sciences

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Xinming Wang, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Abstract:

Hygroscopicity largely affects environmental and climatic impacts of pollen grains, one important type of primary biological aerosol particles in the troposphere. However, our knowledge in pollen hygroscopicity is rather limited, and especially the effect of temperature has rarely been explored before. In this work three different techniques, including a vapor sorption analyzer, diffusion reflectance infrared Fourier transform spectroscopy (DRIFTS) and transmission Fourier transform infrared spectroscopy (transmission FTIR) were employed to characterize six anemophilous pollen species and to investigate their hygroscopic properties as a function of relative humidity (RH, up to 95%) and temperature (5 or 15, 25 and 37 °C). Substantial mass increase due to water uptake was observed for all the six pollen species, and at 25 °C the relative mass increase at 90% RH, when compared to that at <1% RH, ranged from ~30 to ~50%, varying with pollen species. The modified κ -Köhler theory can well approximate the mass hygroscopic growth of all the six pollen species, and the single hygroscopicity parameter (κ) was determined to be in the range of 0.034 ± 0.001 to 0.061 ± 0.007 at 25 °C. In-situ DRIFTS measurements suggested that water adsorption by pollen species was mainly contributed by OH groups of organic compounds they contained. Good correlations were indeed found between hygroscopicity of pollen grains and the amount of OH groups, as determined using transmission FTIR. Increase in temperature would in general lead to decrease in hygroscopicity, except for pecan pollen. For example, κ values decreased from 0.073 ± 0.006 at 5 °C to 0.061 ± 0.007 at 25 °C and to 0.057 ± 0.004 at 37 °C for populus tremuloides pollen, and decreased from 0.060 ± 0.001 at 15 °C to 0.054 ± 0.001 at 25 °C to 0.050 ± 0.002 at 37 °C for paper mulberry pollen.

Highly polar water-soluble organic matter dominates the hygroscopic growth of Indonesian biomass burning particles

JING CHEN

Nanyang Technological University

Wen-Chien Lee, Nanyang Technological University

Masayuki Itoh, Hyogo Prefecture University

Mikinori Kuwata, Nanyang Technological University

Abstract:

Huge amounts of fine particles emitted from the frequently recurred Indonesian peatland fires have been worsening regional air quality directly and affecting human health adversely. Moreover, these wildfire particles can influence the global climate indirectly through the aerosol-cloud-precipitation process, which is closely tied to the water uptake properties especially of the water-soluble organic matter (WSOM) in biomass burning organic particles. However, the water uptake by various types of WSOM could differ significantly due to their complicated chemical constituents. This signifies the importance for deep investigations on the water uptake by different WSOM categories and its connection with more detailed chemical characterizations (e.g., as a function of polarity), yet remains challenging likely due to the ineffective separation of WSOM mixtures.

Here we applied the 1-octanol-water partitioning method (i.e., to separate a series of aqueous- and octanol-phase solutions by varying the 1-octanol:water volume ratio, V_r) into the hygroscopic growth measurements using our home-built humidified tandem differential mobility analyzer (HTDMA), including growth factor measurements of bulk WSOM (A0) and its further segregated more polar (i.e., the aqueous phase, A1) and less polar (i.e., the octanol phase, O1) WSOM fractions in fresh Indonesian biomass burning particles. The corresponding chemical compositions were simultaneously measured using the time-of-flight aerosol chemical speciation monitor (ToF-ACSM).

We experimentally show that order of polarity correlated positively with the particle hygroscopicity parameter, κ , with more polar particles tend to be more hygroscopic. For instance, the values of κ ($D_0 = 100$ nm) for the most polar fractions (A1($V_r = 10$)) were 0.245, 0.170, and 0.288 for WSOM from peat, acacia, and fern combustion, respectively. The least polar fractions (O1($V_r = 0.01$)) were only slightly hygroscopic ($\kappa = 0.004$, 0.017, and 0.021 for peat, acacia, and fern burning particles). These discrepancies in κ results are significantly related to the higher abundance of oxygenated structures and an accompanied lower fraction of high-molecular-weight organics in more polar than those in less polar WSOM solutions.

Further, we have derived the equivalent κ for three WSOM categories which were identified using the positive matrix factorization method (PMF), with assuming that the bulk hygroscopicity is predominantly determined as a linear combination of water uptake by the three WSOM categories. Results show that Factor-1 is the predominant contributor (κ ranges from 0.16 to 0.30), whereas Factor-2 and Factor-3 are almost non-hygroscopic (with κ exclusively below 0.02) thus contribute insignificantly to hygroscopic growth of WSOM. This highlights that only a small fraction of WSOM could contribute to particle hygroscopic growth, which can be further utilized into modeling studies on climate effects resulted by Indonesian biomass burning particles.

Impacts of water partitioning and polarity of organic compounds on secondary organic aerosols over Eastern China

Jingyi Li

Nanjing University of Information Science and Technology

Qi Ying, Texas A&M University

Jianlin Hu, Nanjing University of Information Science and Technology

Jianjun Chen, California Air Resources Board

Haowen Zhang, Nanjing University of Information Science and Technology

Abstract:

Secondary organic aerosol (SOA) is a very important component of fine particulate matter (PM_{2.5}), accounting for 20-50% in urban and rural areas of China[1]. Most air quality models used an equilibrium partitioning method along with estimated saturation vapor pressure of semi-volatile organic compounds (SVOCs) to predict SOA formation. However, this method ignored partitioning of water vapor to the condensed phase as well as the polarity of SVOCs, and might result in significant underestimate of SOA[2]. Here, we used the Community Multi-scale Air Quality model (CMAQv5.0.1) to investigate the above impacts on SOA formation during winter (January) and summer (July) of 2013 over eastern China. The organic aerosol module was updated followed Pankow et al.[2] by incorporating water co-condensation and molecular structure of SVOCs. We also considered the polarity of primary organic aerosols by assuming a bulk composition of 10 surrogate species with different mass fractions following Li et al.[3]. Our model can well reproduce the mass concentration and diurnal variation of PM_{2.5} and major components. SOA concentration shows significant seasonal and spatial variation, with high levels in North China Plain (NCP), Central China and Sichuan basin areas during winter (up to 25 $\mu\text{g m}^{-3}$) and in Yangtze River Delta (YRD) during summer (up to 20 $\mu\text{g m}^{-3}$). By including water co-condensation, we see SOA increases by 20-40% in winter in Eastern China. This process leads to a relatively higher increase of SOA in summer by about 40%-80% in YRD. The polarity of SVOCs and POA exhibits negative effects on SOA formation. SOA concentration varies from -20~-10% to -40~-20% in the high regions in winter and summer, respectively. Condensed water into the SOA portion reaches to 3 and 1.4~3.5 $\mu\text{g m}^{-3}$ in the highly concentrated areas in winter and summer, accounting for 20% and up to 15-20% of the total SOA, respectively. Such variation in both SOA and water content will further alter the physical and chemical properties of aerosols.

Evaluating dominant factors control N₂O₅ uptake: a case study in polluted winter in North China Plain

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Abstract:

The nature of dinitrogen pentoxide (N₂O₅) heterogeneous hydrolysis is important to understand the regional secondary pollution, but the mechanism of N₂O₅ heterogeneous uptake still not well understand. A field campaign was conducted at a suburban site in Beijing, China from January to March 2016. N₂O₅ uptake coefficient, $\gamma(\text{N}_2\text{O}_5)$, was determined by an iterative box model by constraining the observation N₂O₅ and related parameters in polluted days. The observed $\gamma(\text{N}_2\text{O}_5)$ is variable from 0.001 to 0.02, with the average of 0.005. We demonstrate that N₂O₅ uptake was regulated by the suppression

of particulate nitrate and promoted by aerosol liquid water content (ALWC). The derived $\gamma(\text{N}_2\text{O}_5)$ can be predicted by a coupled mechanism that considering chemical compounds (ALWC, nitrate and organic) and size distribution. We highlight the leading importance of ALWC and nitrate in understanding the N_2O_5 heterogeneous hydrolysis and the following environmental impact in North China in wintertime as well as other similar regions.

High relative humidity enhances the particulate diethylamine in an urban area

Yang Chen

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Abstract:

Amine-containing particles were characterized in an urban area of Chongqing during both summer and winter using a single particle aerosol mass spectrometer (SPAMS). Among the collected ambient particles, 12.7% were found to be amine-containing in winter and 8.3% in summer. Amines were observed to co-exist with elemental carbon (EC), organic components, sulfate, and nitrate, suggesting uptake of amines on pre-existing particles. Diethylamine (DEA) was the most abundant among amine-containing particles. Average peak area of DEA depended strongly on humidity, indicating that the enhancement of DEA was due to increasing aerosol water content. Amine-containing particles were mainly originated from the northwest direction in winter where a forest park is located and from the northwest and southwest (traffic hub) directions in summer, suggesting vegetation and traffic as the major sources of amines. Knowledge gained in this study is helpful to understand the atmospheric processing, origin, and sources of amine-containing particles in the urban area of Chongqing.

Routine measurements of atmospheric ice nucleating particles on Tokyo Skytree: Preliminary results in 2016/2017

Yutaka Tobo

National Institute of Polar Research

Jun Uetake, Colorado State University

Yasushi Uji, National Research Institute for Earth Science and Disaster Resilience

Yoko Iwamoto, Hiroshima University

Tatsuhiko Mori, Tokyo University of Science

Kazuhiko Miura, Tokyo University of Science

Ryohei Misumi, National Research Institute for Earth Science and Disaster Resilience

Abstract:

It has been suggested that Asian aerosol outflow has the potential to significantly influence aerosol-cloud interactions on a global scale. However, few measurements on aerosol particles serving as ice nucleating particles (INPs) or cloud condensation nuclei (CCN) have been conducted in Asia. We recently started routine measurements of the number concentrations of aerosols (including both INPs and CCN) and clouds at the 458 m level of Tokyo Skytree (full height: 634 m), which is a television broadcasting tower located in Tokyo, Japan (Misumi et al., 2018). Here, we report on the preliminary results of the measurements of atmospheric INPs on Tokyo Skytree in 2016 and 2017. The number concentrations of INPs active under conditions relevant to mixed-phase clouds at temperatures of 0°C to -25°C have been obtained using our original cold-stage-based droplet freezing technique named the Cryogenic Refrigerator Applied to Freezing Test (CRAFT) system (Tobo, 2016; DeMott et al., 2017). Our results show that the average INP number concentrations measured on Tokyo Skytree were roughly consistent with those measured in Beijing, China (Chen et al, 2018), indicating that the measured values might be background INP number concentrations over urban and industrialized areas in East Asia. In addition, our results suggest the possibility of seasonal variations of the number concentrations of INPs active in a certain temperature regime. In this presentation, we will discuss possible reasons of their seasonal variations.

How do peroxides promote the formation of atmospheric particles?

Zhongming Chen

College of Environmental Sciences and Engineering, Peking University

Abstract:

Peroxides, including hydrogen peroxide (H_2O_2) and organic peroxides (ROOH , $\text{RC}(\text{O})\text{OOH}$, and ROOR), serve as not only important oxidants but also temporary reservoirs for HOx (OH and HO_2) radicals in the atmosphere. H_2O_2 is well known as major oxidant for the transformation of sulfur dioxide (SO_2) into sulfuric acid or sulfate in clouds and fogs, while more and more evidence prove the importance of organic peroxides as constituent of secondary organic aerosol (SOA). Our laboratory studies show that H_2O_2 , SO_2 and carbonyl compounds can be efficiently uptaken onto mineral particles and H_2O_2 produces OH radicals on the surface of particles. The uptake coefficients (γ) of H_2O_2 and peroxyacetic acid (PAA) on ambient $\text{PM}_{2.5}$ particles are determined to be at the order of magnitude of 10^{-4} , and both of $\gamma_{\text{H}_2\text{O}_2}$ and γ_{PAA} increase with increasing relative humidity. It is found that gaseous organic peroxides undergo heterogeneous decomposition on SOA particles and the degree of hydrolysis of newly formed SOA is increased with reaction time, resulting in the production of H_2O_2 . We suggest that peroxides act as a crucial link between sulfate and organic aerosols, which needs further study and should be considered in current atmospheric models. As a conclusion, peroxides help the formation of new particles and the growth and aging of aerosol particles by multiphase reactions.

The yield of inorganic sulfate ion from heterogeneous OH oxidation of organosulfates

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Abstract:

Organosulfates have been frequently detected in ambient aerosols and are important classes of organosulfur compounds. Recent studies have found that some organosulfates can be oxidized efficiently through heterogeneous OH oxidation and generate the inorganic sulfate ions upon oxidation. Although the kinetic and reaction mechanisms were reported, the amount of the inorganic sulfate ion formed upon oxidation has not been examined yet. In this study, an oxidation flow reactor (OFR) is employed to investigate the chemical transformation of sodium methyl sulfate ($\text{CH}_3\text{SO}_4\text{Na}$), the smallest organosulfate detected in the atmosphere, through heterogeneous OH oxidation. The aerosols are collected by Teflon filters before and after oxidation for chemical analysis. The change in abundance of methyl sulfate and the formation of reaction products (i.e., sulfate ion) upon oxidation are quantified by using the ion chromatography (IC). In particular, the yield of inorganic sulfate ion (= amount of sulfate ion formed / amount of methyl sulfate reacted) is determined at different oxidation levels. Our initial results reveal that before oxidation, only the methyl sulfate peak appears in the chromatograph. After oxidation, the intensity of the methyl sulfate peak decreases due to OH oxidation, while the sulfate ion peak evolves and increases with increasing OH exposure. The yield of inorganic sulfate ion is estimated to be about one at an OH exposure of 1.33×10^{12} molecule cm^{-3} s. These results support recent findings that sulfur can be released from the heterogeneous OH oxidation of sodium methyl sulfate. Understanding how inorganic sulfate ions generated from the transformation of organosulfates impacts the abundance of inorganic sulfates in the atmosphere is thus desirable.

Extensive Isoprene Epoxydiols Conversion of Inorganic to Organic Sulfur Alters Aerosol Properties

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Abstract:

Organosulfur compounds are ubiquitous and non-negligible contributors to fine organic aerosol mass in Earth's atmosphere. Among them, sulfate esters or organosulfates (OSs), formed from multiphase chemical processes, are the greatest contributor. While the presence of OSs has been reported in fine aerosol collected from many locations, especially in biogenic-rich areas, the impacts of such products on the physicochemical properties of secondary organic aerosol (SOA) remain unclear. In addition, OSs are suspected to modify the sulfate distribution within the aerosol phase. As sulfate over continental regions is generally of anthropogenic origin, understanding how sulfate impacts the physical and chemical processes associated with SOA formation and properties is crucial to properly representing SOA and sulfate in chemical transport models and evaluating their impacts on climate and human health.

SOA samples collected from the southeastern U.S. and the Amazon forest (isoprene and monoterpene-dominated atmospheres), were chemically characterized to evaluate the concentrations and distributions of fine particulate organosulfur compounds. Speciated OSs and methanesulfonic acid (MSA) were quantified by ultra-performance liquid chromatography interfaced with electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry (UPLC/ESI-HR-QTOFMS). Total organosulfur mass was determined by isotope ratio inductively coupled plasma mass spectrometry and ion chromatography (IC). OSs were found to contribute significantly to the organic aerosol mass in both areas. Surprisingly we found that total quantified OSs plus MSA, however, only accounted for about 50% of total organosulfur. We hypothesize that the missing mass is comprised of sulfate-containing oligomers formed from multiphase chemistry of BVOC oxidation products, especially the isomeric isoprene epoxydiols (IEPOX), with acidic sulfate aerosols.

Chamber experiments re-investigating the multiphase chemistry of gaseous IEPOX and acidic sulfate aerosols targeted atmospheric-relevant IEPOX-to-inorganic sulfate ratios (IEPOX:SO₄). Chamber-generated IEPOX-derived SOA samples were collected by a particle-into-liquid sampler (PILS) every 5 minutes and immediately analyzed by IC and UPLC/ESI-HR-QTOFMS. We found that IEPOX extensively converted inorganic sulfate to organosulfur (up to 90%), which increased with the increasing IEPOX:SO₄. The trend was supported by field measurements reported here and historical data. We further demonstrated that organosulfur greatly modified critical aerosol properties, such as acidity, morphology, viscosity and phase state. In turn, these properties were translated into changes in further reactivity of aerosol particles against IEPOX and properties related to potential impacts on the air quality and climate. Finally, time-resolved chemical data enabled strict constraints on the reaction rate constants forming two major IEPOX-derived SOA tracers — 2-methyltetrols and IEPOX-OS. New rate constants especially for IEPOX-OS was higher by at least two orders of magnitude compared to those that are currently used in the models.

Overall, our findings provide a comprehensive picture of particle-phase processing governing isoprene-derived SOA composition and suggest that the pivotal role of IEPOX-OSs in SOA formation and evolution. An improved modeling approach adopting updated particle-phase kinetics as well as capturing the changing aerosol physical properties induced by the chemistry is necessary to properly represent SOA in the models and evaluate the impact of industrial activity on the past, current and future air quality and climate.

Abundance of Organosulfates in China: Seasonal and Spatial Contrasts

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Abstract:

Organosulfates (OSs) derived from biogenic volatile organic compounds (BVOCs) represent an important class of products formed between anthropogenic sulfur pollution and natural emissions. However, a lack of systematic study of distribution of OSs under different pollution conditions in ambient samples presents a significant obstacle to quantify this chemical interaction between human and nature. In this work, we quantified OSs and nitrooxy OSs (NOSs) in four urban and rural sites including Beijing (BJ), Shanghai (SH), Guangzhou (GZ) and Hong Kong (HK) from the north to south of China during summer 2016 and winter 2017. Sixteen OSs and five nitrooxy OSs derived from dicarboxylic acid, isoprene, monoterpene, and sesquiterpene were quantified using a high-performance liquid chromatogram coupled to ultra-high resolution orbitrap mass spectrometer. During our sampling days, the total concentrations of detected OSs and NOSs ranged between 7.6-36.1 ng/m³, 7.6-59.2 ng/m³, 9.1-46.8 ng/m³ and 2.4-28.5 ng/m³ in BJ, SH, GZ, and HK site, accounting for 1.3‰, 2.7‰, 0.9‰ and 1.0‰ of the corresponding PM_{2.5} mass respectively. The seasonal average concentrations of isoprene OSs and dicarboxylic acid OSs were much higher in summer than in winter. Spatially, GZ site showed the most abundant concentration followed by SH, HK and BJ, indicating the BVOCs was the major influence factor for isoprene and dicarboxylic acid OSs formation. Mono/sesquiterpene OSs and NOSs showed a clear seasonal fluctuation with a peak in winter as well as good correlations with sulfate and nitrate. The highest concentration of Mono/sesquiterpene OSs and NOSs appeared in BJ, followed by SH, GZ and HK, suggesting the importance of anthropogenic sulfur and nitrate pollution to formation of mono/sesquiterpene OSs and NOSs. The seasonal and spatial contrasts for OSs/NOSs provide insights on mechanistic knowledge about this group of secondary organic aerosol molecules.

The effect of temperature, humidity and seed aerosol acidity on secondary organic aerosol (SOA) from the photo-oxidation of isoprene

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Abstract:

Isoprene (C₅H₈) is a major biogenic volatile organic compound known to contribute up to 70% of secondary organic aerosol (SOA) in some areas (Li et al., 2018). In the atmosphere, isoprene reacts with hydroxyl radicals (OH), ozone (O₃) and nitrate radicals (NO₃) producing various SOA compounds. The formation and composition of these SOA compounds depend on the temperature, relative humidity (RH) and presence of aerosol seed particles (Zhang et al., 2011; Clark et al., 2016). Understanding the effects of temperature, RH and aerosol acidity can significantly improve the accuracy of both regional and global SOA models.

In this study, SOA formation from the photo-oxidation of isoprene was investigated using the AURA smog chamber facility at Aarhus University (Kristensen et al., 2017) at temperatures of 258–293 K, RH of 0–50% and with/without ammonium sulfate seeds at two pH values. A gas chromatograph coupled with flame ionization detector (GC-FID) and high resolution time of flight aerosol mass spectrometer (HR-ToF-AMS) were used for the online measurements of the gas phase and particle phase concentrations respectively. A scanning mobility particle sizer (SMPS) system including electrostatic classifier coupled with a water-based condensation particle counter (CPC) was used to record particle size distributions. Filter samples collected during the experiment were analyzed using an ultrahigh performance liquid chromatography coupled to electrospray ionization source of quadrupole time-to-flight mass spectrometer (UHPLC/ESI-qTOF-MS) and an UHPLC/ESI-Orbitrap-MS.

Our study shows that the SOA formation and chemical composition from the photo-oxidation of isoprene is highly related to the experimental temperature and RH. The influence of aerosol seed acidity on individual aerosol compounds (e.g., organosulfates) is also examined and will be discussed.

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Fresh and aged combustion aerosols: Chemical composition and molecular biological/toxicological effects on air-liquid-interface exposed human lung cells

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Abstract:

Aerosol emissions from combustion sources, such as car or ship engines, biomass combustion or industrial processes can cause severe health effects. The acute re-sponse of lung cells onto combustion aerosols includes cytotoxicity, genotoxicity oxidative stress, inflammation or cell death (apoptosis or necrosis). Chronic exposure of humans with the immission of those sources is linked with cardiovascular diseases, cancer or lung diseases (e.g. asthma, COPD). Only few links between aerosol chemical composition and biological effects have been established yet. In the framework of the Virtual Helmholtz Institute-HICE (www.hice-vi.eu), physical and chemical properties of combustion emissions as well as their biological effects on lung cells (human epithelial cells, A549, BEAS2B, primary cells and murine macro-phages, RAW) are jointly analyzed. For validation purposed selected animal exposure experiments were conducted (BL6 mice). The chemical composition and physical parameters of the emissions were thoroughly characterized, using GC-MS, FTICRMS, ICP-MS, on-line photoionization mass spectrometry and aerosol mass spectrometry etc. For addressing the biological activity/toxicity of the aerosols, lung cell-cultures were realistically exposed by novel air-liquid interface (ALI) exposure-systems. After 4h exposure biological effects were analyzed by classic toxicological assays and a multi-

omics characterization (transcriptomic, proteomic and metabo-lomics level). Emissions of wood-pellet- and log wood-stoves, ship engines, car die-sel- and gasoline-engines were investigated by this approach using two field-deployable ALI-exposure-station systems and a mobile S2-bio safety laboratory. Af-ter exposure biological effects were comprehensively characterized (viability, cyto-toxicity, multi-omics) and are put in context with the chemical and physical aerosol data (for the concept: [Oeder et al., PLoSone2015]). Interestingly, the observed bio-logical response-strength differs considerably for different aerosol sources and is not well correlated to the deposited PM2.5-mass, pointing towards large differences in the relative toxicity of the aerosol emissions from different combustion sources and fuel types. Furthermore adverse and protective effects are observed. The latter find-ings are supported by detailed analyses of activated cellular response pathways (e.g. GO-term analysis), depicting regulation of biological pathways such as pro-inflammatory signaling, xenobiotic metabolism, phagocytosis or oxidative stress and findings from the animal exposure experiments. Recently the experiments were ex-panded to the investigation of simulated atmospherically processed emission aero-sols (UV-aging simulated in photochemical oxidation flow tube with Ozone addition). Interestingly many known organic air-toxicants, such as most polycyclic aromatic hydrocarbons (PAH), are strongly reduced by the photo-oxidation procedure. A spe-cial flow tube is used (PEAR tube from the UEF) which allow to generate sufficient flow to enable ALI-expose of lung cells as well as animal exposure validation tests with the aged aerosols. Furthermore, wall loss effects are minimized by implement-ing a sheath flow and laminar flow conditions. Although many air toxicants are re-duced by the aging, first results suggest that the cytotoxicity of aged aerosols is in-creased. Volatile reactive compounds, such as aldehydes or partly oxidized aromatic systems may be responsible for the observed effects.

Atmospheric aging affects the toxicity of the emissions from wood and lignite combustion

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Abstract:

It is well known that combustion emissions cause adverse effects for human health, including significant burden of morbidity and premature mortality. In many areas, small-scale combustion causes a significant effect on the local air quality, which impairs human health. Wood and coal use in the domestic heating and cooking comprises a large share of the small-scale combustion emissions.

We studied the effects of wood (spruce) and brown coal (lignite) combustion in a small-scale fireplace designed for domestic heating. The emissions were diluted by porous tube and ejector diluters and led to direct exposures of the cells and mice either via atmospheric aging or as fresh diluted emissions. A549 cells were exposed for 1 h in a thermophoretic exposure device, designed for emission aerosols and nanoparticles, whereas C57-bl6 mice were exposed in an inhalation chamber, 4 hours a day in 3 consecutive days. From the cell exposures both cell and culture medium samples were collected for subsequent analyses of cytotoxicity, genotoxicity, inflammation and oxidative stress. From the exposed mice, blood sample, bronchoalveolar lavage fluid (BALF) and lung tissue samples were collected under terminal anesthesia. For the cell cultures, the results were compared to the clean air exposed cells, whereas for the mice, untreated group acted as a control.

All samples caused some toxic effects for the cells. Fresh wood smoke was somewhat more cytotoxic to the cells when compared to lignite combustion emissions. Atmospheric aging increased the cytotoxicity of both emissions but the difference was clearer with the lignite combustion emissions. For oxidative stress, the fresh spruce combustion aerosol caused slightly larger effect than the corresponding lignite derived aerosol. For the IL-8 chemokine production, lignite combustion aerosol caused larger effect than the respective spruce combustion sample. In this case, spruce combustion aerosol was inducing larger effect after the aging, whereas no clear effect was seen for the lignite aerosol.

In the parallel experiments with mice, we saw indications of aerosol induced changes in the lungs. In the BALF cells, we detected clearly visible amounts of soot agglomerates inside the cells. The amount of the particles seemed to be larger for the spruce emission exposed animals, when compared to respective lignite aerosol exposure. For the cytokine concentrations, the levels were equal for the both exposures. Both exposures increased the cytokine concentration, but the increase was much greater for the lignite combustion aerosol. In genotoxicity analysis, the fresh wood combustion emission induced larger effect than respective lignite aerosol. Aging did not change the effects a lot, but the order between the samples was different to the fresh aerosol samples.

In conclusion, we saw differences in the toxicological effects between different fuels and due to atmospheric aging process both in the cell and animal models. Parallel exposures with the mouse inhalation chamber and the air-liquid-interface cell exposure systems showed that the exposure system can be successfully used in the emission studies and the methods are sensitive enough to see the differences between the samples. The cell and animal results were complementary to each other.

Effects of oxidative processing on particle-bound reactive oxygen species formation from incense burning and cooking fumes

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Abstract:

Reactive oxygen species (ROS, e.g. OH radical, H₂O₂ and organic peroxides), whether present in respirable particles or generated by other particle components upon their deposition in the lung, are widely thought to be a significant contributor to particle-related toxicity. ROS can induce oxidative stress, causing damage to lipids, proteins and DNA. Recent studies have shown that substantial amounts of particle-bound ROS (e.g., organic peroxides) are present in secondary organic aerosol (SOA), which can be produced in the atmosphere through oxidative processing of volatile organic compounds (VOCs) and existing organic aerosols (OA). However, the major sources of particle-bound ROS and the effects of oxidative processing of anthropogenic OA on particle-bound ROS formation in both indoor and outdoor environments remain largely unexplored.

This work aims to investigate the formation of particle-bound ROS from incense burning and cooking emissions, which have been considered as major particle sources in some indoor and outdoor microenvironments, especially in Asian cities and urbanized region. We quantify the total peroxide content, one of the major particle-bound ROS, in the water-soluble fraction of aerosol filter samples (with and without ozone processing) using a fluorescence probe, 2,7-dichlorofluorescein (DCFH), in conjunction with catalytic enzyme horseradish peroxidase (HRP). Since the proposed fluorescence probe can react with any organic peroxides in different extent, the overall peroxide concentrations in aqueous samples are presented in a unit of H₂O₂ equivalent concentration. Our preliminary results show that the water-soluble fraction of OA generated from both incense burning and heated cooking oil contain detectable amounts of total peroxide (TP). The total peroxide-to-total organic carbon (TP/TOC, nM of H₂O₂ equivalent concentration/ppm of TOC) ratio for aerosol particles generated from heated cooking oil is much higher than that for incense burning emissions, suggesting a higher TP formation potential from cooking emission. While ozone exposure enhances the TP/TOC ratio of cooking emissions substantially, the TP/TOC ratio of incense burning emissions remains roughly the same after ozonolysis. The TP formation potential of these two urban sources will be further compared with laboratory-generated SOA produced by a flow tube reactor system.

Implications of photochemical ageing for source apportionment and health effects of wood combustion aerosol

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Abstract:

The combustion of logwood in residential stoves has been identified as substantial contributor to local air pollution. It releases high levels of particle-bound polycyclic aromatic hydrocarbons (PAH) and oxygenated PAH (OPAH), in the range of 0.1% - 1% of the total emitted particulate matter (PM). However, in the atmosphere those compounds undergo chemical transformation along with physical transformation of PM, which changes the toxicity of wood combustion emissions. Degradation kinetics of particle-bound PAH and OPAH are mainly affected by the particle composition and microstructure. Gas phase PAH, in contrast, have higher differences in reactivity with OH, O₃ and NO₃ and are less affected by direct photolysis.

In this study, we aged combustion aerosol from spruce logwood with a recently described high-flow oxidation flow reactor, "Photochemical Emission Aging flowtube Reactor" (PEAR) (Ihalainen et al. (2019), *Aerosol Science & Technology*) and investigated the effect of ageing on emissions of PAH and OPAH as well as PAH diagnostic ratios for emission source identification. Moreover, genotoxicity of primary and aged emissions were assessed in 4 h in vitro exposures of A549 cells by comet assay. Finally,

carcinogenicity of the emissions based on PAH toxicity equivalent (PAH-TEQ) was determined and compared to emissions from a non-road diesel engine as reference for carcinogenic emissions “group 1”.

The combustion of spruce logwood released 404 $\mu\text{g MJ}^{-1}$ of 35 analysed PAH and 299 $\mu\text{g MJ}^{-1}$ of 10 analysed OPAH, most of which are known potential mutagens and carcinogens. Photochemical processing by PEAR substantially degraded particle-bound PAH, which was also reflected in declining PAH-TEQ by 45 to 80% per equivalent day of photochemical ageing. However, the wood combustion aerosol would require more than four days of photochemical ageing to reach comparable TEQ of diesel exhaust particles, a carcinogen of “group 1”, from a 24.5 kW non-road diesel engine. Compared to PAH, OPAH were less affected by photochemical ageing, supposedly due to additional secondary formation.

Genotoxicity increased significantly from clean air control to both primary and aged aerosol as assessed by comet assay. However, despite substantial degradation of carcinogenic PAH, the genotoxicity between primary and aged spruce combustion aerosol remained comparable. Furthermore, exposure to filtered primary and aged aerosol decreased the DNA damage, but not below the significance level of 5%, which highlights the importance of the gas phase for the underlying cellular mechanisms.

Diagnostic ratios to identify wood combustion emissions in ambient air remained stable during photochemical ageing for PAH species PHE/ANT, FLA/PYR, RET/CHR, and IcdPYR/BghiPER. On the other hand, BaP/BeP and BaA/CHR allow monitoring of the photochemical age.

This study motivates more detailed investigation of the consequences of photochemical ageing on toxicity and identification of wood combustion emissions in ambient air.

Detection of toxic metals in the atmosphere: Development of a low-cost spark-induced breakdown spectroscopy (SIBS) system

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Abstract:

Toxic metals are listed as Hazardous Air Pollutants (HAPs) by United States Environmental Protection Agency (USEPA). Conventional techniques for metal detection, such as inductively coupled plasma mass spectrometry (ICP-MS) and X-Ray fluorescence (XRF), suffer from cumbersome sample preparation and poor time resolution. To address recent interest in inexpensive, portable sensors, we have developed a novel, portable, modular and yet affordable instrument to quantify toxic metals in the atmosphere using spark-induced breakdown spectroscopy (SIBS). A plasma is formed by discharging a capacitor at high voltage ($\sim 4500\text{V}$) to ablate the samples deposited on a 1 mm diameter tungsten rod. Compared to common SIBS set-ups that employ expensive iCCD cameras, an elliptical mirror is used to reduce the instrument cost and improve the plasma emission collection efficiency. The instrument is able to detect multiple elements with a single discharge shot. The modularity of the instrument enables inexpensive components to be used when cost is a constraint or more expensive components when high sensitivity and resolution are required. Various HAPs were analyzed to establish the instrument limits of detection. This novel technique provides an alternative tool to quantify PM metals in a fast and affordable fashion.

Differential toxicities and contributing components in urban PM_{2.5}

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Abstract:

The global exercise in estimating outdoor PM_{2.5}-attributable mortalities relies on strong assumptions about equal toxicity per total inhaled dose. Recent epidemiological and in vivo evidence has placed these assumptions under scrutiny. This study tested the hypothesis that in vitro toxicological properties per unit mass concentration of PM_{2.5} vary among cities due to differing mixtures of toxic components.

We first compared the potencies of PM_{2.5} collected from Beijing and Guangzhou in January 2014 to induce cytotoxicity and reactive oxygen species (ROS) in human bronchial epithelial cells. The concentration-effect analysis showed greater toxic potencies of the PM_{2.5} samples from Beijing than those from Guangzhou at equal mass concentrations. The targeted chemical analysis revealed higher burden of metals and polycyclic aromatic hydrocarbons (PAHs) per unit mass of PM_{2.5} in Beijing. The mixture-toxicity experiments and modelling testified that the mixtures of metals and PAHs detected in the PM_{2.5} samples acted in a concentration-additive manner towards their joint effects on ROS induction. The results supported the quantitative attribution of each individual components to the overall effects of PM_{2.5}. The identified chemicals (metals + PAHs) explained 38% and 24% of PM_{2.5}-induced ROS in Beijing and Guangzhou, respectively. PAHs contributed approximately twice the share of the PM_{2.5} effects as metals. The three transition metals, Fe, Cu, and Mn, dominated >80% of the metal-shared effects. Dibenzo[a,l]pyrene alone explained >65% of the PAH-shared effects. The significant contribution from coal combustion and vehicular emissions in Beijing underlies the major source disparities of toxicologically-active PAHs between the two cities.

In a second study, we compared the potencies of PM_{2.5} collected from Nanjing and Guangzhou in winter 2016 to induce ROS and pro-inflammatory cytokine (interleukin-6 or IL-6) in human alveolar epithelial cells. PM_{2.5} samples from Nanjing exhibited greater potencies in inducing ROS than, and similar potencies in inducing IL-6 to, those from Guangzhou. The targeted chemical analysis revealed higher burden of metals, PAHs, and endotoxins per unit mass of PM_{2.5} from Nanjing. Using bacterial lipopolysaccharides (LPS) as a model endotoxin, endotoxins was estimated to account for a large proportion of PM_{2.5}-induced ROS and IL-6 in both cities, outcompeting the summed contribution of metals and PAHs. The dominance of endotoxins was confirmed by 16S rRNA sequencing. Endotoxin-producing Gram-negative bacteria shared >60% of the total bacteria in PM_{2.5}, with Proteobacteria as a dominant phyla. The current findings highlighted the need to consider both chemical and microbial components in the toxicity assessment of PM_{2.5} mixture.

Our study provided novel insights into the role of varying toxic component profiles in shaping the disparate toxic properties of PM_{2.5} among different cities. Systematic investigations with a broader seasonal and geographical coverage will enhance our understanding of the toxicity evolution of city-specific PM_{2.5} pollution over spatiotemporal scales. Such quantitative information can be incorporated into the current exposure-response assessment framework that relies solely on the PM_{2.5} mass concentration for refined risk estimates.

Long-term study of aerosol extinction-to-backscatter ratio with combination of micro-pulse LIDAR and AERONET over northern Taiwan

Sheng-Hsiang Wang

National Central University

Shantanu Kumar Pani, National Central University

Neng-Huei Lin, National Central University

Abstract:

Atmospheric aerosols play a crucial role and govern the regional/global radiation budget. However, uncertainties in their compositions, characteristics, size-distributions, concentrations, and vertical-distributions throughout the atmospheric column make the exact quantification of their overall impact challenging. Especially their vertical distributions are less and unevenly distributed over the globe. Because of their wide spatial and temporal variability, our understanding of the aerosol vertical structure is still very limited. The knowledge on aerosol vertical distributions mostly gained over worldwide was from in-situ probing using rocket and balloon-borne instrumentations, and satellite remote-sensing. Among all, the Light Detection and Ranging (LIDAR) method has been proved to be very useful to characterize the aerosol vertical profiles and used during many field experiments worldwide. East Asia is the most complex region in the world for the aerosol studies as it encounters lot of varieties of aerosols and aerosols type classification could be challenge in this region. In this study, continuous and long-term (2005–2012) observations of micro pulse lidar (MPL) and Aerosol Robotic Network (AERONET) were made at National Central University, Taoyuan (24.97°N, 121.18°E; 133 m above sea level) over a rural location in northern Taiwan. These observations were used to get aerosol optical characteristics, retrieval of extinction coefficient profile, and the estimation of aerosol extinction-to-backscatter ratio (S_p) to explore the nature of aerosols under different seasons over northern Taiwan. Aerosol vertical extinction profiles retrieved from MPL measurements were categorized into near-surface and two-layer transport types. The annual mean aerosol optical depth (AOD at 500 nm), angstrom exponent (AE at 440 and 870 nm), and S_p were 0.41 ± 0.28 , 1.25 ± 0.33 , and 53 ± 21 sr, respectively, with the highest monthly AOD in March (0.75 ± 0.23 ; higher by a factor of ~ 2) attributed to the upper layer (3–6 km) transport of biomass-burning aerosols from Indochinese peninsula. Moreover, the S_p values for several major air pollutants that affects northern Taiwan area was estimated and the results were compared with previous studies. Finally, our study summarized the S_p values for four major aerosol types viz., urban (S_p : 42 ± 18 sr), marine (30 ± 12 sr), dust (34 ± 6 sr), and biomass-burning (69 ± 12 sr) over the study location, and their source origins were also verified on the basis of air mass backward trajectories analysis. Other important findings will be presented. This study provides not only

an accurate retrieval of aerosol extinction coefficient profiles, but also significant important information for climate studies in northern Taiwan.

Temporal and spatial characteristics of aerosol chemical composition retrieved from POLDER/PARASOL observations over Asia from 2005 to 2013

Lei LI

Chinese Academy of Meteorological Sciences

Huizheng CHE, Chinese Academy of Meteorological Sciences

Abstract:

The information about composition of atmospheric aerosols has a great importance for various aspects of monitoring and understanding of climate and environment dynamics. Such information can be obtained using in situ measurements or chemical transport model simulation. However, in situ sampling has limited spatial and temporal coverage, while model estimations have large uncertainties. The present work enables the monitoring of aerosol chemical species from satellites providing observationally-based results with spatial and temporal coverage. Following the ideas of Schuster et al. (2005, 2009, 2016) we relate complex refractive index with aerosol chemical composition. However, in contrast with Schuster's approach, the composition is retrieved directly from remote sensing measurements without passing via intermediate retrieval of actual values of refractive index; the approach that reduces uncertainties and provides additional constraints in case of limited sensitivity of observations. The challenge is the identification of the model adequately linking refractive index to chemistry. The effort has focused on identifying an optimal "physico-chemistry to refractive index" conversion model. With that purpose, we first tested the retrieval approach using a simplified volume-weighting model that links complex refractive index to fractions of chemical components such as black carbon (BC), brown carbon (BrC), dust, iron oxides, soluble inorganic salts, aerosol water content, in fine and coarse size fractions of aerosol. Then the model was updated by using the Maxwell Garnett mixing rule. The retrieval concept was incorporated into the versatile GRASP algorithm (Dubovik et al. 2014), which has been designed to retrieve an extended set of atmospheric parameters from diverse remote sensing observations. Then a series of sensitivity tests using synthetic data of POLDER/PARASOL polarimeter data were conducted, and these tests were followed by inversion of real POLDER/PARASOL observations. The sensitivity tests showed that utilization of both the volume-weighted and Maxwell Garnett based models allows the retrieval to distinguish amongst the assumed chemical species. Results derived by POLDER/PARASOL data from 2005 to 2013 demonstrated good agreement with the optical characteristics provided by AERONET (e.g., r of ~ 0.95 or higher for aerosol optical thickness). In addition, the obtained patterns of chemical component distribution agreed with known physical expectations. For example, the mass concentrations of black and brown carbon are very high during the biomass burning season. On the contrary, the mass concentration of dust and iron oxides are very high over the dust

region. Surface BC measurements in China were also employed to validate our aerosol chemical composition retrievals.

Aerosol height retrieval using space-borne Vis hyperspectral sensor based on O₄ absorption: New applications of spatiotemporal O₄ Column Densities and Temperature-Dependent O₄ Absorption Cross Section

Wonei Choi

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Hanlim Lee, Division of Earth Environmental System Science Major of Spatial Information Engineering, Pukyong National University

Abstract:

We developed an aerosol effective height (AEH) retrieval algorithm using the O₄ air mass factor (AMF) at 477 nm from the hyperspectral Ozone Monitoring Instrument (OMI). Topographical and seasonal O₄ vertical column density (VCD) effect on AEH retrieval accuracy has been evaluated using our AEH retrieval algorithm. In addition, the effect of a temperature-dependent cross-section for O₄ (TDCS) on Look Up Table (LUT)-based AEH retrieval accuracy was quantified. TDCS is found to further enhance AEH retrieval accuracy compared with an O₄ absorption cross-section at a single temperature of 293 K (SCS), when spatial and seasonal dependency of O₄ VCD is applied to the LUT in our algorithm. In comparison between the retrieved AEH and those from NIES lidar network for the period from January 2005 to June 2009, when both the TDCS and seasonal and topographical O₄ VCDs are applied, a Root Mean Square Error (RMSE) is calculated to be 0.44 km for both smoke and dust types. However, when both a TDCS (SCS) and a single O₄ VCD value were applied to the LUT, the RMSE for both aerosol types is 0.52 km (0.51 km). It implies that TDCS contributes most to AEH retrieval accuracy when accurate O₄ VCDs are applied to the LUT. For smoke aerosols only, both TDCS and multiple O₄ VCD (SCS and single O₄ VCD) applications had RMSE value of 0.46 km (0.66 km). Based on synthetic radiances, we also investigated the effects of uncertainties in our algorithm input data such as O₄ VCD, TDCS, aerosol type, AOD, and surface reflectance on AEH retrieval error. It was found that large errors are attributable to uncertainties in O₄ VCD, AOD, and surface reflectance compared with those of TDCS and aerosol type. Especially, an O₄ VCD uncertainty of about 140% caused AEH errors more than 4.3 km.

Probing aerosol acidity at three sites during a 2015 intensive observation period in Taiwan

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Neng-Huei Lin, Dept. of Atmospheric Sciences, National Central University

Abstract:

Aerosol acidity is a crucial chemical parameter influencing aerosol composition and in turn the public health and radiative forcing impacts of aerosols. This work is an extension of the study by Pani et al., (2017) examining the aerosol data collected during an intensive observation period (IOP) in fall 2015 covering five sites in Taiwan and Japan. In this follow-up, data from the Taiwan sites is used to estimate the pH of aerosols at each site and probe the possible differences temporally, spatially and across size bins and the causes therein. pH estimates by ion balance, neutralization ratios, partitioning theory and thermodynamic models are contrasted and compared. Data from this IOP reveals distinct site-dependent characteristics of the aerosol pH and indicates a wide range of possible pH across size bins, which has climate change and air quality impacts. These findings strongly suggest the need to track aerosol pH closely in future East Asian measurement campaigns.

Cloud scavenging of anthropogenic refractory particles at a mountain site in North China

Weijun Li

School of Earth Sciences, Zhejiang University

Lei Liu, School of Earth Sciences, Zhejiang University

Abstract:

Aerosol-cloud interactions remain a major source of uncertainty in climate forcing estimate. Few studies have been conducted to characterize the aerosol-cloud interactions in heavily polluted conditions worldwide. In this study, cloud residual and cloud interstitial particles were collected during cloud events under different pollution levels from 22 July to 1 August, 2014 at Mt. Tai (1532 m above sea level) located in the North China Plain. A transmission electron microscope was used to investigate morphology, size, and chemical composition of individual cloud residual and cloud interstitial particles, and to study mixing properties of different aerosol components in individual particles. Our results show that S-rich particles were predominant (78%) during clean periods ($PM_{2.5} < 15 \mu g m^{-3}$), but a large amount of anthropogenic refractory particles (e.g., soot, fly ash, and metal) and their mixtures with S-rich particles (named as S-refractory) were observed during polluted periods. Cloud droplets collected during polluted periods were found to become an extremely complicated mixture by scavenging abundant refractory particles. We found that 76% of cloud residual particles were S-refractory particles and that 26% of cloud residual particles contained two or more types of refractory particles. Soot-containing particles (i.e., S-soot and S-fly ash/metal-soot) were the most abundant (62%) among cloud residual particles, followed by fly ash/metal-containing particles (i.e., S-fly ash/metal and S-fly ash/metal-soot, 37%). The complicated cloud droplets have not been reported in clean continental or marine air before. Our findings provide an insight into the potential impacts on cloud radiative forcing from black carbon and metal catalyzed reactions of SO_2 in micro-cloud droplets containing soluble metals released from fly ash and metals over polluted air.

The Change of Anthropogenic PM_{2.5} since 1850 and its Global Climate Effects

Hua Zhang

State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences

Dongdong Yang, Nanjing University of Information Science and Technology

Abstract:

Anthropogenic PM_{2.5} plays important roles not only in environment and human health, but also in climate change. First, we investigated the temporal and spatial distribution of anthropogenic PM_{2.5}; then studied the effective radiative forcing (ERF) due to the PM_{2.5} and its climatic effects over the globe, especially over regions with high air pollution, by using the aerosol-climate coupled model of BCC_AGCM2.0_CUACE/Aero in this paper. Results show that the column burden of anthropogenic PM_{2.5} has generally increased over the globe, especially over the South Africa, as well as the south and east parts of Asia. Strong negative ERF since the pre-industrial can be found with the increase in the PM_{2.5} concentrations, and the global annual mean ERF between 1850–2010 is -2.3 W m^{-2} , with -0.4 W m^{-2} and -1.9 W m^{-2} as aerosol-radiation interaction (ERF_{ari}) and aerosol-cloud interaction (ERF_{aci}), respectively. The negative ERF is stronger over East Asia, Southeast Asia, and the nearby oceans than other areas. The global annual mean surface net radiative flux (SNRF) and surface air temperature (SAT) have decreased by 5.38 W m^{-2} and 2.26 K , respectively. A strong cooling over the oceans in the mid and high latitudes of the Northern Hemisphere (NH) caused a southward shift of the Intertropical Convergence Zone (ITCZ), which effect is totally consistent with all anthropogenic aerosol's. Both the global annual mean precipitation and surface water flux have decreased by $\sim 0.18 \text{ mm day}^{-1}$, whereas the surface relative humidity has increased by $\sim 0.23\%$. Generally, the PM_{2.5} concentration change made most contributions (>92%) to the total variations in the ERF, SAT, SNRF, precipitation, cloud fraction, surface relative humidity (SRH) compared to all anthropogenic aerosols.

Diesel Black carbon aging under urban atmosphere using a QUasi-atmospheric Aerosol evoLutlon sTudY (QUALITY) chamber

Weizhao Xu

Peking university

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Kefan Liu, Peking university

Ying Yu, Peking university

Rui Tan, Peking university

Jun Zhang, Tsinghua University

Zhou Zhang, Tsinghua University

Shijin Shuai, Tsinghua University

Song Guo, Peking university

Zhijun Wu, Peking university

Min Hu, Peking university

Abstract:

Black carbon (BC) is the byproduct from incomplete fossil fuel combustion and biomass burning. As the second climate agent, BC can directly and indirectly affect the radiation by scattering and absorbing light, and forming cloud as cloud condensation nuclei. The fresh emitted BC undergoes various chemical and physical processes, which is called BC aging. The BC properties can significantly change during aging. However, the mechanism of BC aging is still unclear. In this study, the aging of BC particles emitted from diesel engine was simulated using QUasi-atmospheric Aerosol evoLutlon sTudY (QUALITY).

Our results showed that the morphology of the BC particles changed during aging process. The large particles, i.e. 220 nm, collapse more significant than the smaller ones, i.e. 150 nm. The increase of particle mass, effective density and decrease of shape factor were governed by the coating thickness. After aging for 2.5 hours, the effective density increased from 0.5 to 1.3 g/cm³, and the shape factor is near to 1. The mass absorption coefficient (MAC) was not significant during the beginning of aging. For 220nm soot particle, the MAC enhancement can reach 1.3. The BC particle core was measured by heating the particles to 350°C using a thermo denuder. BC core becomes compact after aging. The effective density of BC core can reach ~1 g/cm³, suggesting the fresh BC was void-filled at the same time. The results of this study highlight the variation of morphology, mixing state, optical

properties of BC particles in different initial sizes. The results can be applied to improve the global climate model.

The trend of black carbon concentration at 3 background monitoring stations of China, from 1990s to 2017

Jie Tang

Meteorological Observation Center, China Meteorological Administration

Mian Wang, 1) Meteorological Observation Center, China Meteorological Administration

Qianli Ma, 2) Lin'an regional GAW station, Zhejiang meteorological bureau

Hao Wu, 3) Waliguan global GAW station, Qinghai meteorological bureau

Yanan Li, 1) Meteorological Observation Center, China Meteorological Administration

Peng Yan, 1) Meteorological Observation Center, China Meteorological Administration

Huaigang Zhou, 4) Shangdianzi regional GAW station, Beijing meteorological bureau

Abstract:

In this study, we developed the pilot scale two stage vortex wet scrubber system to achieve high particulate removal efficiency while minimizing maintenance costs. There are deflectors in two stage vortex wet scrubber to create turbulence by passing the gas at relatively high velocities through the nozzle. The curved baffle causes the water to fall back like waves leading to turbulence in the water column within the inner compartment. Therefore, the pilot scale two stage vortex wet scrubber system is simple in operation and represents high performance with no additional electrostatic force. The fly-ash was used as test dust and the particle concentrations were measured with a portable laser aerosol spectrometer (Model 1.108; Grimm GmbH., Germany). The mean particle size of test dust was 3.7 μm . Results from the test exhibit a high particulate removal efficiency of above 98%.

The impact of the aerosol direct radiative forcing on deep convection and air quality in the Pearl River Delta region

YIM, Hung-Lam Steve

Department of Geography and Resource Management, The Chinese University of Hong Kong

Steve H.L. Yim, Z. Liu, C. Wang, N.C. Lau

Abstract:

Literature have reported the remarkable aerosol impact on low-level cloud by direct radiative forcing (DRF). Impacts on mid-upper troposphere cloud are not yet fully understood, even though this knowledge is important for regions with a large spatial heterogeneity of emissions and aerosol concentration. We assess the aerosol DRF and its cloud response in June (with strong convection) in Pearl River Delta region for 2008-2012 at cloud-resolving scale using an air quality-climate coupled model. Aerosols suppress deep convection by increasing atmospheric stability leading to less evaporation from the ground. The relative humidity is reduced in mid-upper troposphere due to induced reduction in both evaporation from the ground and upward motion. The cloud reduction offsets 20% of the aerosol DRF. The weaker vertical mixing further increases surface aerosol concentration by up to $2.90 \mu\text{g}/\text{m}^3$. These findings indicate the aerosol DRF impact on deep convection and in turn regional air quality.

Parallel Oral Session V

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

29 May 2019 (Wednesday) | 13:30 – 15:30

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Aerosol chemistry (4) Co-chair(s) 1. Thorsten Streibel, University of Rostock 2. Yanlin Zhang, Nanjing University of Information Science and Technology	Thorsten Streibel, University of Rostock	Chemical Characterization of Particulate Matter from Combustion Devices Related To Wood Combustion And Internal Combustion Engines	13:30-13:45	Mr and Mrs Lau Tat Chuen Lecture Theatre (LT-5)
	Mengren Li, Chinese Academy of Sciences	Stable carbon isotope composition and source indication in the Western Taiwan Strait region	13:45-14:00	
	Yanlin Zhang, Nanjing University of Information Science and Technology	Heterogeneous Formation of Nitrate Aerosols under Ammonium-rich Regime during the high PM2.5 events in Nanjing, China	14:00-14:15	
	Xiao Li, Peking University	Light Absorption Characteristic of Nitroaromatic Compounds in Particulate Brown Carbon in PKUERS Beijing	14:15-14:30	
	Qiongqiong Wang, The Hong Kong University of Science and Technology	Online Measurement of Individual Organic Compound in Ambient Aerosol Using Thermal Desorption Aerosol Gas Chromatography and Mass spectrometry (TAG)	14:30-14:45	
	Bin-Yu Kuang, Hong Kong University of Science & Technology	Analysis of polycyclic aromatic hydrocarbons by ammonium formate addition – ESI (+) FT-ICR MS for PM2.5 sample from Pearl River Delta	14:45-15:00	
	Yun Zhang, Johannes Gutenberg University	Organic chemical composition by Orbitrap MS and oxidative potential of particulate aerosols	15:00-15:15	
Remote sensing (2) Co-chair(s) 1. Ronald Macatangay, Atmospheric Research Unit, National Astronomical Research Institute of Thailand 2. Jason Cohen, Sun Yat-Sen University	Ronald Macatangay, National Astronomical Research Institute of Thailand (<i>Invited Speaker</i>)	Atmospheric LIDAR Research and Operations at the National Astronomical Research Institute of Thailand	13:30-14:00	Chan Kei Biu Lecture Theatre (LT-6)
	Kang-Ho Ahn, Hanyang Univeristy	Vertical Aerosol Distribution and Flux Measurement in the Planetary Boundary Layer Using Drone	14:00-14:15	
	Ying Zhang, Chinese Academy of Sciences	Estimation of aerosol chemical components in atmospheric column based on Fine and Coarse Mode Separation (FCMS) method from ground-based remote sensing measurements	14:15-14:30	
	Zeng Zhaoliang, Wuhan University	Preliminary evaluation of the Atmospheric Infrared Sounder water vapor over China against high-resolution radiosonde measurements	14:30-14:45	
	Jason Cohen, Sun Yat-Sen University	Using Multiple Remotely Sensed Platforms, Ground Measurements, Mesoscale and Mie Models in Tandem with a Variance Maximization Approach to Improve our Understanding of Rapidly Changing Aerosol Emissions, Extreme Aerosol Events, and Long-Range Transport/In-Situ Processing of Asian Aerosols	14:45-15:00	
	Shuang Zhang, Lanzhou University	Preliminary Exploration of Active and Passive Remote Sensing of Aerosol Characteristics in Arid and Semi-arid Eurasian Continent and the Trend of Aerosol Variation with Meteorological from 2007 to 2016 under the Background of Global Warming	15:00-15:15	
Aerosol-climate-meteorology (2) Co-chair(s) 1. Tetsuya Takemi, Kyoto University 2. Tzung-May Fu, Southern University of Science and Technology	Tetsuya Takemi, Kyoto University (<i>Invited Speaker</i>)	High-resolution modeling of atmospheric dispersion in urban districts and complex topography	13:30-14:00	SAE Magnetics Lecture Theatre (LT-9)
	Tzung-May Fu, Southern University of Science and Technology (<i>KC Wong Foundation Invited Speaker</i>)	Anthropogenic Aerosols Inhibit Occurrences of Mesoscale Convective Systems in April over Southern China	14:00-14:30	
	Chiu Tung Cheng, The University of Tokyo	Development of size-resolving aerosol microphysics scheme for use in a global non-hydrostatic cloud-resolving model	14:30-14:45	
	Meng Gao, Harvard University	Seasonal Prediction of Indian Wintertime Aerosol Pollution using the Ocean “Memory” Effect	14:45-15:00	
	Guicai Ning, Chinese University of Hong Kong	Classification of winter synoptic patterns in the northwest Sichuan Basin, China and their impacts on air quality	15:00-15:15	
Special symposium: Aerosol-water interaction (2) Co-chair(s) 1. Mijung Song, Chonbuk National University 2. Ye Kuang, Institute for Environmental and	Mijung Song, Chonbuk National University	Liquid-liquid phase separation in organic particles: importance of the average O:C	13:30-13:45	Peter Ho Lecture Theatre (LT-10)
	Youngchul Song, Chonbuk National University	Kinetics of Water Transport in Ultraviscous Organic Aerosol: Aerosol viscosity	13:45-14:00	
	Zhe Chen, Beijing Institute of Technology	Volatile or not? For HNO ₃ from Mg(NO ₃) ₂ droplets- measurements by vacuum FTIR and aerosol optical tweezer	14:00-14:15	
	Jie Chen, Peking University	Primary and secondary surface-active organics are important Ice nucleating particles	14:15-14:30	
	Guohua Zhang, Chinese Academy of Sciences	A look at the formation of oxalate by single particle mass spectrometry	14:30-14:45	
	Zhe Wang, The Hong Kong Polytechnic University	Cloud chemistry and interaction with aerosols at a mountain site in Hong Kong	14:45-15:00	

Climate Research, Jinan University	Ye Kuang, Jinan University	A novel method for calculating ambient aerosol liquid water content based on measurements of a humidified nephelometer system	15:00-15:15	
	Mikinori Kuwata, Nanyang Technological University <i>(Invited Speaker)</i>	Less than half of water-soluble organic matter contribute to hygroscopic growth: an application of 1-octanol-water extraction method	15:15-15:30	
Urban aerosol and air quality (1) Co-chair(s) 1. Chung-Te Lee, National Central University 2. Keith Ngan, City University of Hong Kong	Chung-Te Lee, National Central University	Temporal and spatial distribution of PM2.5 chemical components and their effects on atmospheric light extinction	13:30-13:45	Leung Ko Yuk Tak Lecture Theatre (LT-14)
	Keith Ngan, City University of Hong Kong	Vertical dependence of regional and local pollutants	13:45-14:00	
	Ben Liu, University of Macau	Vertical Measurements of Black Carbon (BC) and Ozone (O3) Using Miniature Devices Onboard an Unmanned Aerial Vehicle at A Suburban Site in Guangzhou, China	14:00-14:15	
	Yi Li, Sunset-CES Inc.	Data Quality Control System—the Key to Sensor Application in Air Quality Monitoring Network	14:15-14:30	
	Xinming Jin, Tsinghua University	Dynamic aerosol exposure risks of pedestrians during walking along the street canyon	14:30-14:45	
	Huy Ninh Xuan, National Cheng Kung University	The effect of vegetation barrier on the dispersion of ultrafine particles in a wind tunnel	14:45-15:00	
	Sarkawt Hama, Univeristy of Surrey	Inflow and outflow budget analysis of ambient particulate matter and trace gases in Delhi-NCR region of India	15:00-15:15	
	Gwi-Nam Bae, Korea Institute of Science and Technology	Overview of the National Strategic Project on PM2.5 Air Pollution in Korea	15:15-15:30	

Chemical Characterization of Particulate Matter from Combustion Devices Related To Wood Combustion And Internal Combustion Engines

Thorsten Streibel

University of Rostock

Hendryk Czech, University of Rostock

Jürgen Orasche, Helmholtz Zentrum München

Toni Miersch, University of Rostock

Martin Sklorz, University of Rostock

Johannes Passig, Helmholtz Zentrum München

Olli Sippula, University of Eastern Finland

Jorma Jokiniemi, University of Eastern Finland

Benjamin Stengel, University of Rostock

Bert Buchholz, University of Rostock

Ralf Zimmermann, Helmholtz Zentrum München

Abstract:

Combustion related aerosol emissions exhibit a considerable impact on human health and the climate. They contribute to a large extent to the formation of ambient aerosol, which is known to cause adverse health effects. Although the association between ambient aerosols and adverse health effects is very well established by epidemiology, it is still not well understood which aerosol fractions or properties are responsible for the observed effects.

For a better understanding of these interrelations, a thorough chemical characterization of the emitted particulate matter from various combustion sources is of high importance. In the framework of the Virtual Helmholtz Institute HICE, intense measurement campaigns have been carried out devoted to a comprehensive analysis of the chemical patterns of particles produced by different combustion sources. Utilized measurement techniques comprised filter sampling for particulate matter followed by chemical analysis using hyphenation between a thermal/optical carbon analyzer (EC/OC analyzer) and a photo-ionization time-of-flight mass spectrometer (PI-TOFMS). In addition, gas chromatography/mass spectrometry with in-situ derivatization after thermal desorption of the filters was carried out.

Different combustion sources have been investigated in this manner. Particulate emissions of wood combustion compliances, namely a logwood operated masonry heater and a pellet boiler have been

investigated. For the masonry heater, spruce and pine wood served as fuel. Pine wood emitted significantly higher amounts of organic compounds than spruce wood. The pellet boiler showed considerable lower emission factors with respect to organic substances.

Particles originating from diesel exhaust of a stationary engine were investigated as well. An interesting aspect was the observation that wood combustion particles exhibited higher contents of polycyclic aromatic hydrocarbons (PAH). However, simultaneous exposure experiments with lung cell cultures revealed less severe biological responses on transcriptome and proteome level when exposed to wood combustion aerosol. Possible mitigating effects of phenolic compounds are discussed to explain this result.

Aging of the emitted aerosol was realized by a flow-tube reactor to investigate the potential of wood combustion aerosol for the formation of Secondary Organic Aerosol. PAH toxicity measured as toxic equivalency factor (TEQ) decreased in aged aerosol compared to primary emitted particulate matter.

A further combustion source consisted of a gasoline engine test bench. The engine was run with gasoline containing 10 % of ethanol and with E85, a mixture of 85 % ethanol and 15 % gasoline. Two driving cycles were applied, one reflecting urban traffic, the other driving with high velocities between 80 and 180 km/h for four hours. E85 showed much lower emission of particles and aromatic species, but high gas phase emissions of unconsummated ethanol and acetaldehyde. Driving with high velocities using E10 fuel led to a perceptible increase of PAH and carbon monoxide emissions.

Stable carbon isotope composition and source indication in the Western Taiwan Strait region

Mengren Li

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Yanting Chen, Institute of Urban Environment, Chinese Academy of Sciences

Youwei Hong, Institute of Urban Environment, Chinese Academy of Sciences

Jinsheng Chen, Institute of Urban Environment, Chinese Academy of Sciences

Abstract:

The Western Taiwan Strait region, or the Urban Agglomerations on the West Side of the Straits, including about 20 cities in Fujian Province, Zhejiang Province, and Guangdong Province, is a new special developing economy cluster in southeast coast of China. The Western Taiwan Strait region was influenced by the East Asia monsoon greatly, and provided an active environment for the interactions between the continent and the ocean. With the rapid economic development, air pollution has become a severe public affair and drawn extensive attention. In order to understand the regional level and source contributions of PM_{2.5} pollution in the Western Taiwan Strait region, filter samples were collected in seven sites in this region, including four urban sites (Fuzhou, Xiamen, Ningde, and Longyan), one suburban site (Ningbo), one remote site (Pingtan), and one mountain site (Mt. Wuyi) in the successive four seasons, using the Four-Channel samplers and the High-Volume samplers simultaneously. Teflon filters were used to measure the mass concentration, the water-soluble ions and the trace elements, while quartz filters were used to analyse the carbonaceous components (elemental carbon and organic carbon), POM (Particulate Organic Matter) and the stable carbon isotope. The PM_{2.5} mass concentrations were higher in winter and autumn than in spring and summer, so did the concentration of carbonaceous components. Substantial secondary organic formation has happened during the sampling periods. Significant regional pollution episodes were observed in each season at the all seven sites. To investigate the source origins and variations during the pollution episodes, as well as the transport paths along the coastline, stable carbon isotope analysis was conducted, respectively. Between the two major kinds of fossil sources, the contribution of vehicle emission was much higher than coal combustion. The major anthropogenic source in the urban sites and the suburban site was vehicle emissions, while the biogenic source contributed more to the remote site and the mountain site. The seasonal features suggested higher vehicle emission contribution in winter and autumn while more from biogenic source in spring and summer. C₃ plant was the dominant biogenic source. The biogenic source contribution proportions could increase in some specific pollution periods, with the impact of both source emissions and various meteorological conditions.

Heterogeneous Formation of Nitrate Aerosols under Ammonium-rich Regime during the high PM_{2.5} events in Nanjing, China

Yanlin Zhang

Nanjing University of Information Science and Technology

Yuchi Lin, Nanjing University of Information Science and Technology

Abstract:

Nitrate (NO₃⁻) is a major component of PM_{2.5} (particulate matters with aerodynamic diameter less than 2.5 μm) in urban polluted air. It not only influences the regional climate, but also contributes acidification of terrestrial and aquatic ecosystems. In 2016 and 2017, several intensive on-line measurements of water-soluble ions in PM_{2.5} were carried out in Nanjing City, in order to characterize the water-soluble ions and investigate the potential formation mechanism of airborne particulate NO₃⁻. During the sampling periods, NO₃⁻ was the most predominant species with an average abundance of 36 % in total water-soluble ions (TWSIs), followed by sulfate (SO₄²⁻, 32 %) and ammonium (NH₄⁺, 23 %). Higher theoretical equilibrium constants (PHNO₃·PNH₃) between partitioning of aerosol- and gas-phase NO₃⁻ and NH₄⁺ along with lower observed PHNO₃·PNH₃ explained the declined NO₃⁻ concentrations in the summertime. However, significant enhancements of nitrate aerosols in both absolute concentrations and abundances suggested that NO₃⁻ was a major contributor to the fine particles during the high PM_{2.5} events (hourly PM_{2.5} ≥ 150 μg m⁻³). Utilizing the molar ratios of NO₃⁻/SO₄²⁻ and NH₄⁺/SO₄²⁻, we found that high NO₃⁻ concentrations occurred mainly under NH₄⁺-rich conditions and the ratio of nitrate to “excess-NH₄” was close to a unity. This implied that formation of nitrate aerosols in Nanjing has to be involved with NH₃ in the atmosphere. Low aerosol acidity can give reasonable explanation for this atmospheric chemistry behaviors. In the high PM_{2.5} events, nitrogen conversion ratios (Fn) positively correlated with aerosol liquid water content (ALWC, R² = 0.55, p < .05). Meanwhile, increasing NO₃⁻ concentrations coincided regularly with increasing ALWC and decreasing Ox (Ox = O₃ + NO₂), which is an indicator for capacity of atmospheric photochemistry. This suggested that nitrate formation was due to the reaction of HNO₃ produced by N₂O₅+H₂O with primary emission gas NH₃. Based on the observed data, we also estimated the average formation rate of NO₃⁻ concentrations by heterogeneous process was 13.8 % h⁻¹, which was 2.6 times higher than that (5.3 % h⁻¹) of homogeneous reaction. This suggested that heterogeneous reaction accelerated more NO₃⁻ aerosol formation; resulted in abrupt enhancements of nitrate concentrations in the PM_{2.5} episodes in Nanjing City. However, in our case, ammonium nitrate aerosol formation was HNO₃-limitation, suggesting that control in emissions of its precursor, NO_x, will be able to reduce nitrate aerosols efficiently and decrease the PM haze formation in this industrial city.

Light Absorption Characteristic of Nitroaromatic Compounds in Particulate Brown Carbon in PKUERS Beijing

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Abstract:

Brown carbon (BrC), the light-absorbing organic fraction in atmospheric aerosols, is characterized by strong wavelength dependence of light absorption from ultraviolet (UV) and visible (vis) light. Light absorption properties of BrC have significant effects on climate change and air quality in terms of radiative forcing and visibility impairment. The BrC molecular compounds have recently attracted much attention due to their poorly characterized molecular structures. In this work, the light-absorbing properties and chemical compositions of BrC were comprehensively investigated based on field observation studies in summer and winter in urban Beijing.

Ambient PM_{2.5} filter samples were collected at an urban site of Beijing in winter (Jan 1-31, 2016) and summer (May 16-June 9, 2016). The light absorption of methanol extracted BrC from PM_{2.5} were measured using UV-vis spectrophotometer. The overall molecular compositions of BrC were characterized by an ultrahigh resolution Orbitrap mass spectrometer (MS). A total of 12 nitroaromatic compounds (NACs), as a major fraction among BrC, were then quantified using ultrahigh performance liquid chromatography (UHPLC) coupled to Orbitrap MS, and the light absorption by NACs were also discussed.

Particulate BrC in PM_{2.5} had a light absorption coefficient of 107 Mm⁻¹ and 30 Mm⁻¹ at 370 nm in summer and winter, respectively. Particulate BrC contributed over 40% of the total light absorption in PM_{2.5} at 370 nm in winter, and about 16% in summer. The ultrahigh resolution MS analysis suggested that the compounds containing C, H, O and C, H, O, N elements were the major components of methanol extracted BrC in PM_{2.5}. 12 specific NACs, a major fraction among BrC, were also analyzed to elucidate its contribution to light absorption by BrC. The average concentrations of 12 quantified NACs were 172.1 ± 135.6 ng/m³ in winter, 19 times higher than those in summer (8.9 ± 4.0 ng/m³). The total light absorption by NACs contributed about 9.1% and 3.5% of the total BrC light absorption. The obvious enhancements of light absorption by NACs in winter could be attributed to more primary emissions. Conspicuous difference between day and night could be seen in winter, while no significant difference in summer, relating to both emission sources and formation pathways.

This work elucidated the presence of abundant BrC and its enhanced light absorption in urban atmospheres, whereas their molecular compositions, specific light-absorbing properties, and atmospheric stability were poorly characterized. Further studies should be conducted to identify the most important BrC constituents emitted from different sources, including chemical composition characterizations, optical properties, formation mechanisms and parameters affecting the overall light absorption of BrC.

Online Measurement of Individual Organic Compound in Ambient Aerosol Using Thermal Desorption Aerosol Gas Chromatography and Mass spectrometry (TAG)

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Abstract:

Organic species are important tracers to indicate pollution sources and aerosol formation mechanism, however the application of which are severely hindered by the coarse time resolution with the traditional offline filter measurement. In this study, online measurement of particulate molecular-level organic species in ambient PM_{2.5} was achieved using thermal desorption aerosol gas chromatography and mass spectrometry (TAG) with in-situ derivatization in urban Shanghai in a three-week field campaign in 2018. This is the first study employing TAG in mainland China to monitor the dynamic variation of trace organic species in field. A large number of organic species including both non-polar (e.g. C₁₆-37 n-alkanes and polycyclic aromatic hydrocarbons (PAHs) with molecular weight from 178 to 278) and polar classes (e.g. C₄-9 dicarboxylic acids, aromatic acids, fatty acids and sugars) were quantified with a time resolution of every two hour. The variation of internal standards (ISs) during the campaign showed relative standard deviation of 13-19% for non-polar ISs and 24-70% for polar ISs. Larger variation of polar ISs indicated the derivatization efficiency was influenced by other factors such as aerosol loadings, suggesting the necessity of representative IS to achieve reliable quantification of a large number of target compounds. Diurnal variation of selective markers was examined. The high time resolution was capable of capturing the characteristics of corresponding sources and aerosol formation. Primary organic aerosol (POA) tracers such as benzo[ghi]perylene showed clear early morning and afternoon peaks, indicating vehicle-related sources, while secondary organic aerosol (SOA) tracers such as phthalic acid showed higher concentrations at day time, suggesting photochemical formation. The rich dataset is promising to aid in real time source apportionment when combined with other real-time measurement to capture short-term pollution source variations.

Analysis of polycyclic aromatic hydrocarbons by ammonium formate addition – ESI (+) FT-ICR MS for PM2.5 sample from Pearl River Delta

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Abstract:

Aromatic compounds, such as PAHs, exist in atmospheric aerosols, and many of them are toxic. It is necessary to detect as many aromatic compounds as possible to understand the toxicity in aerosols. Electro spray ionization (ESI) is not favorable for detecting non-polar species, but previous study discovered that adding Ammonium formate (AF) in the solution can facilitate ESI⁺ ionizing non-polar aromatic species. This study focuses on utilizing this AF addition method to comprehensively analyze PAHs and other aromatic compounds for a large number of ambient samples, and studying the influence of AF addition on ESI⁺ ionization. Twenty-four ambient PM_{2.5} samples were collected in Pearl River Delta (PRD) region, and their dichloromethane (DCM) extracts adding AF were directly injected into ESI⁺ Fourier-transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) to characterize organic compound formulas. The PAHs of high detection frequency are in two groups: (1) DBE (double bond equivalent) 4~13 and C number 13~35 and (2) DBE 15~30 with compact structures. These frequently detected PAHs are potential important species in ambient, worth future quantification and toxicity study, and those high-DBE PAHs are possibly linked to brown carbon (BrC), because larger conjugated system makes the UV-vis absorption shifting to higher wavelength of visible light. Comparing with the PAHs detected by APPI previously, more PAHs with high DBE or high C number (up to C₄₀H₇₄ for alkylbenzenes) were observed. It indicates that, AF addition with ESI⁺ has advantages of both APPI (allow detecting high-DBE formulas) and ESI (detecting high C number formulas). Adding AF, much more formulas are detected for non-polar species (PAHs), and low polarity species e.g. PAHs derivative of low O numbers. While some other species of lower intensity and the species whose signal cannot be enhanced by AF were suppressed. Thus, it indicates that, ESI⁺ without AF and with AF are two

complementary methods, and it is suggested to detect formulas using both methods, to obtain comprehensive results of toxic compounds in organic aerosols.

Organic chemical composition by Orbitrap MS and oxidative potential of particulate aerosols

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Abstract:

There is increasing evidence that particulate matter (PM) is harmful to human health since especially fine particles can enter the respiratory and cardiovascular system. Volatile organic compounds (VOCs), whether of biogenic or anthropogenic origin, are well-established precursors for the formation of organic aerosol matter (OM). Particularly for source apportionment, the identification of sources and elucidation of formation and atmospheric aging mechanisms requires a detailed knowledge of the molecular composition of OM. Organic aerosols are a highly complex mixture that undergoes continuous atmospheric transformations for which suitable instrumentation is needed. A relatively new technique to analyze organic aerosol particles is offered by the Orbitrap mass analyzer. Under certain conditions, ultrahigh-resolution MS (UHRMS) allows the unambiguous determination of the elemental formula for each ion signal, due to the high mass resolving power and high mass accuracy. At the same time recent studies have shown that the redox active species in OM can generate considerable amount of reactive oxygen species (ROS), which can induce biologic damages. However, the relative contribution of different organic species in OM to total ROS formation remains to be elucidated.

In this study, we quantified the H₂O₂ yield and dithiothreitol consumption rate of ambient PM_{2.5} (PM diameter \leq 2.5 μ m) and laboratory secondary organic aerosols (SOA) and also explored the chemical composition of organic constituents at the molecular level using Orbitrap MS coupled with ultra-high-performance liquid chromatography (UHPLC). We found the oxidation state of organic constituents is in positive correlation with the H₂O₂ yield and dithiothreitol consumption rate, indicating the close correlation of highly oxidized compounds with the oxidative potential or ROS formation. The correlations of different organic species with the oxidative potential of ambient PM_{2.5} will also be discussed.

Atmospheric LiDAR Research and Operations at the National Astronomical Research Institute of Thailand

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Abstract:

Air pollution in Thailand is caused by several factors including land cover changes, land use changes (which lead to agricultural waste burning and forest fires as a result of the proliferation of commercial contract farming), chemistry (such as the conversion of volatile organic compounds into secondary organic aerosols) and transboundary transport, modulated by the topography and eventually by mountain meteorology and the resulting boundary layer dynamics. The planetary boundary layer, also called the atmospheric boundary layer or mixing layer, is a turbulent layer of the atmosphere which is in constant heat, water vapour and pollutant exchange with the earth's surface with a temporal response of an hour or less. Complex terrain can complicate this exchange through mountain and advective venting. In this work, we present data from two deployed mini-micropulse lidar instruments in Chiang Mai and Songkhla in northern and southern Thailand, respectively. We have found out that the lidar-derived mixing height explains around 16% (r-squared) of the particulate matter variations over the Chiang Mai valley during the dry season. We have also seen an approximately 15-day cycle of the maximum mixing layer height probably associated with the passage of high and low pressure systems. We also show a recent short measurement campaign performed at the Mae Hia Chiang Mai University Agriculture Campus utilizing an unmanned aerial vehicle for measuring thermodynamic properties of the atmosphere and mass concentrations of atmospheric particles from which the mixing height can be derived and compared to lidar measurements. Preliminary data on lidar-observed high-altitude dust (approximately 3 km) both in Chiang Mai and Songkhla will be presented as well as the recent inclusion of these two lidar systems to the NASA MPLNet.

Vertical Aerosol Distribution and Flux Measurement in the Planetary Boundary Layer Using Drone

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Abstract:

Vertical particle size distribution, total particle concentration, wind velocity, temperature and humidity measurement is performed with a drone. The drone is equipped with a wind sensor, house-made optical particle counter (Hy-OPC), condensation particle counter (Hy-CPC), GPS, Temperature, Relative Humidity, Pressure and communication system. In many cases, application or maneuvering of drone at high altitude may cause unexpected failure of system that will might be a catastrophic for the researchers. To ensure the safety of the drone system, we tested for horizontal wind and vertical wind speed up to 10 m/s with an open wind tunnel. In addition, a low temperature durability test was also performed in Mongolia in winter at the temperature of -30°C . High altitude test was performed many times up to 2,500 m a.s.l. Moreover, when one motor fail situation was tested and the drone was safely return to the ground. When GPS signal was lost, the drone can return to base automatically. Above all, the drone system is fully automatically operated for take-off and landing. So these features will ensure the less dependency of the operator proficiency.

Base on the wind velocity and the particle size vertical distribution measurement with drone, the particle mass flux was calculated. The vertical particle distribution showed that the particle number concentration was very strongly correlated with the relative humidity

Estimation of aerosol chemical components in atmospheric column based on Fine and Coarse Mode Separation (FCMS) method from ground-based remote sensing measurements

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Abstract:

Aerosols have adverse effects on human health and air quality, changing Earth's energy balance and lead to climate change. The components of aerosol are important because of the different spectral characteristics. Based on the low hygroscopic and high scattering properties of organic matter in fine modal atmospheric aerosols, we develop an inversion algorithm using remote sensing to obtain aerosol components including black carbon (BC), organic matter (OM), ammonium nitrate-like (AN), dust-like (DU) components and aerosol water content (AW). The algorithm consists of two steps. Firstly, the microphysical characteristics (i.e. VPSD and CRIs) of particulates are preliminarily separated to fine and coarse modes based on the Fine and Coarse Modes Separation (FCMS) method. And then aerosol components are retrieved by using bimodal parameters. We execute the algorithm using remote sensing measurements of Sun-sky radiometer at AERONET site (Beijing RAD1) in a period from October of 2014 to January of 2015. The results show a reasonable distribution of aerosol components and a good fit for spectral feature calculations. The mean OM mass concentration in atmospheric column is account for 14.93% of the total and 56.34% of dry and fine mode aerosol, being a fairly good correlation ($R = 0.56$) with the in-situ observations near the surface layer.

Preliminary evaluation of the Atmospheric Infrared Sounder water vapor over China against high-resolution radiosonde measurements

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Abstract:

The accuracy of Atmospheric Infrared Sounder (AIRS) water vapor product in China is as yet unknown due to the lack of collocated in-situ sounding observations. This study conducts a preliminary assessment for the performance of AIRS water vapor mixing ratio (q) and precipitable water vapor (PWV) products in China using high-resolution soundings at 1400 Beijing time from 113 radiosonde sites across China in June 2013 and June 2014. Comparison analysis between AIRS and radiosonde data suggests that the correlation coefficient (R) of these two kinds of q data in China exhibits a distinct geographical discrepancy, with highest R in most arid Northwest China. The mean bias (MB) suggests that AIRS q tends to be underestimated in Southeast China, but to be overestimated in Northwest China. This spatial pattern is most likely due to the spatial contrast in cloud distribution across China. In terms of the height-revolved distribution, the q from both AIRS and radiosonde tends to decrease with increasing altitudes, irrespective of sub-regions. AIRS PWV products and radiosonde PWV maintain good consistency in spatial distribution except for in southern China with AIRS PWV being underestimated. The accuracy of AIRS water vapor tends to be impaired under high cloudy conditions (especially overcast conditions). This indicates that cloud is a key factor impacting the accuracy of AIRS water vapor. Our findings highlight the importance of validating AIRS data against simultaneous sounding observations, and have significant implications for improved understanding of water vapor under global warming.

Using Multiple Remotely Sensed Platforms, Ground Measurements, Mesoscale and Mie Models in Tandem with a Variance Maximization Approach to Improve our Understanding of Rapidly Changing Aerosol Emissions, Extreme Aerosol Events, and Long-Range Transport/In

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Sun Yat-Sen University

Abstract:

Using a variance maximization approach across multiple aerosol and trace gas remotely sensed measurements on the decadal time-scale, we have developed an approach to quantify both changes in aerosol sources as well as events of abnormal intensity in both space and time. Some of the most important findings are related to missing sources, changes in source regions, and approximation of the chemical aging/lifetime of aerosols. Model variability in terms of ratios between the source trace gasses and aerosols, in-situ lifetimes, and optical/chemical connections via a mie core/shell mixed model allow us to determine specific impacts associated with changes in urbanization, biomass burning, and under what conditions long-range transport is important. And given the rapid rate of change of source strengths and locations, as well as the complex meteorology over Asia, we find this technique compares much better than other commonly used techniques over East Asia, Southeast Asia, and South Asia.

This approach will be demonstrated in terms of added value in terms of quantifying sources and impacts of aerosols from both short but intense biomass burning events, as well as due to urban expansion. We have found that under such rapidly changing conditions, which are generally clean on average but are heavily polluted a certain fraction of the time, that we can obtain a successful quantification of both BC and inorganic aerosol emissions and loadings. Furthermore, that such findings compare better with AERONET measurements of extreme events and aerosol SSA and size across Asia, with the exception of Japan.

Our results also provide insights into how emissions databases can be and should be improved, and what types of aerosol and meteorological in-situ processing the models will need to improve in order to match more closely with the suite of observations. Under heavily polluted conditions, our improvements are noticeable but also show the yawning gap that we still need to address, especially with respect to conditions where the boundary layer is unstable or where local forcings overwhelm the large-scale balance conditions.

We conclude with four points. First, that an estimation of aerosol emissions from regions through to previously have zero aerosol sources. Second, that urban emissions are more diffuse in space than current datasets give them credit for. Third that the assumption of a strong boundary layer is frequently

not realistic. And finally, that long range transport is important even in what are otherwise thought to be megacities dominated by local sources.

Preliminary Exploration of Active and Passive Remote Sensing of Aerosol Characteristics in Arid and Semi-arid Eurasian Continent and the Trend of Aerosol Variation with Meteorological from 2007 to 2016 under the Background of Global Warming

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Abstract:

In this paper, the temporal and spatial distribution characteristics of aerosol particles in arid and semi-arid regions of Eurasia from 2007 to 2016 were studied by using Moderate-resolution Imaging Spectroradiometer (MODIS)-Aqua, Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) - Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) and Ozone Monitoring Instrument (OMI)-Aura data, and The distribution of aerosol optical depth(AOD), angstrom exponent(AE) and aerosol single scattering albedo(SSA) in the region with 10-year average, seasonal and annual trends was analyzed. The changes of drought index, wind speed and temperature were analyzed under the background of 10-year temperature rising trend. The results show that the 10-year AOD in Xinjiang, Pakistan and India, Kyrgyzstan, Tajikistan, Turkmenistan, Iran and Iraq have higher concentration, coarser and stronger absorption capacity. 10-year zonal mean aerosol concentration is higher at 70 degrees E-90 degrees E, the 10-year meridional mean aerosol concentration is higher at 38 degrees N-42 degrees N. Ten-year average seasonal aerosol concentrations in Xinjiang, Iraq, Iran, Kazakhstan, Uzbekistan and Turkmenistan were the highest in spring, the second in summer and the lowest in autumn and winter from MODIS and CALIPSO. The concentration of aerosols at the junction of Pakistani Costa and India was the highest in summer, the second in autumn and the lowest in winter and spring from MODIS and CALIPSO. Vaguely visible from MODIS, it can be seen that the soot aerosol produced in winter heating in northern China makes the aerosol concentration higher in winter, especially in northern Xinjiang. CALIPSO makes up for the lack of MODIS data in winter. From CALIPSO, it can be clearly seen that the soot aerosol produced in winter heating in northern China makes the aerosol concentration higher in winter, especially in northern Xinjiang. In the southern part of Kazakhstan, Uzbekistan and Turkmenistan centered on the Aral Sea, MODIS AOD values are higher than CALIPSO AOD values in all seasons. MODIS aerosol concentration tends to decrease in the southwest of Kazakhstan, the Aral Sea, the border between Pakistan and India, and the northern Xinjiang of China, while it tends to increase in other selected areas. The 10-year trend of drought index, precipitation and surface wind speed was studied, and the 10-year variation of MODIS AOD with temperature was also

studied. The results showed that the regional average AOD increased with the increase of temperature in 10 years.

High-resolution modeling of atmospheric dispersion in urban districts and complex topography

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Abstract:

Understanding of atmospheric dispersion in urban districts and/or complex topography is important for analyzing and predicting air quality and thermal conditions in such areas. With the increase in the population and industrial/economic activities in cities, urban areas have more and more densely built, high-rise buildings. The complexity of geometrical features of surface roughness due to man-made buildings and structures affects the characteristics of turbulent flow and dispersion in the atmosphere. For the numerical analysis on the turbulent dispersion, both microscale turbulence and mesoscale/synoptic-scale processes should be represented in the simulations. This study investigated turbulent flow and dispersion in urban districts under real meteorological settings by conducting high-resolution numerical simulations with both the Weather Research and Forecasting (WRF) model and a large-eddy simulation (LES) model. First, the results of high-resolution meteorological simulations of atmospheric dispersion with the use of the WRF model are provided for cases of volcanic ash dispersion from the Sakurajima Mountain, Japan. Sakurajima is located very close to the urban area of Kagoshima and thus is a great threat to the city. By comparing the simulated wind fields with the field measurements, we demonstrate how the accuracy of the simulated wind fluctuations affect the representation of atmospheric dispersion of volcanic ash released from the vent of Sakurajima. It was indicated that turbulent flows generated by not only by Sakurajima but also by surrounding terrains strongly control the local-scale dispersion and deposition of volcanic ash. Next, as an example of the atmospheric dispersion problem, the turbulence and dispersion measured in Oklahoma City during the field experiment Joint Urban 2003 were simulated by the present WRF/LES modeling. Overall the simulated results well reproduced the boundary-layer flow and structure. The simulated dispersion fields agreed well with the field measurements in some locations; however, in other cases the simulation disagreed with the measurements, because even a slight departure of the simulated winds to the measurements may result in a large discrepancy of the simulations from the observations.

Anthropogenic Aerosols Inhibit Occurrences of Mesoscale Convective Systems in April over Southern China

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Abstract:

We simulated the mesoscale convective systems (MCSs) over Southern China in April of 2009 and 2010 with and without anthropogenic emissions of aerosol and precursors, with the goal of evaluating the impacts of anthropogenic aerosols on the springtime precipitation and MCS occurrences over Southern China. During the study period, the domain-average aerosol number concentrations at the surface over Southern China were ten times in the polluted simulation than that in the clean simulation. Relative to the clean simulations, the April domain-total rainfall in the polluted simulations decreased by 16% and 8.5% in 2009 and 2010, respectively, mainly as a result of reduced convective precipitation. These simulated precipitation changes in response to increased aerosol concentrations were consistent with the observations, which showed a 25% decrease in precipitation over Southern China in April during the years 2001 to 2011 (polluted period) relative to the years 1979 to 1989 (clean period). In addition, the number-hours of developed MCSs in the polluted simulations were lower than those in the clean simulations by 44% and 25% in 2009 and 2010, respectively, due to lower surface temperature, less convective available potential energy, less moisture advection, as well as weaker updraft and low-level wind shear. We found that the direct radiative effect of aerosols was not the main driver for the thermodynamic changes responsible for the reduced precipitation and MCS occurrences over Southern China in April. Instead, aerosols increased the optical depth of low clouds, which indirectly altered the surface thermodynamic conditions, which in turn inhibited MCS occurrences. This complex feedback between aerosols, low clouds, and MCSs leading to significant changes in precipitation have important implications for the impacts of aerosols on climate.

Development of size-resolving aerosol microphysics scheme for use in a global non-hydrostatic cloud-resolving model

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Abstract:

Aerosol-cloud interactions is one of the biggest uncertainties in estimating aerosol forcing to the climate. The key factors determining the cloud condensation nuclei (CCN) ability of aerosols are the vertical velocity and aerosol size. However, general circulation models (GCMs) usually cannot resolve both factors. Thanks to the advancement of computer powers, global cloud-resolving models (GCRMs) have been developed in recent years. With fine spatial resolutions, GCRMs can spatially resolve vertical velocity. On the other hand, the size of aerosols is typically described by modal approaches due to its wide size range.

Given that the particle size affects aerosol's CCN ability as well as their lifetimes and optical properties, it is essential to better represent the aerosol particle sizes, taking advantage of GCRMs for more realistic simulations of aerosol-cloud interactions and more reliable quantification of climatic impacts of aerosols. This motivates us to develop a size-resolving microphysical scheme for use in our aerosol-coupled GCRM, i.e. the Nonhydrostatic Icosahedral Atmospheric Model (NICAM) coupled with Spectral Radiation-Transport Model for Aerosol Species (SPRINTARS).

We develop the size-resolving scheme as an extension from the original NICAM-SPRINTARS framework. In this presentation, early results from the ongoing model development will be described, including its validation through comparisons to ground-based observations from AERONET and satellite observations from MODIS.

SPRINTARS predicts the mass mixing ratios of four major atmospheric aerosol species: sea salt, mineral dust, sulfate and carbonaceous aerosols. In original version of NICAM-SPRINTARS, the sizes of sea salt and dust are described by 4 and 10 bins, respectively. A more flexible bin-type size representation is introduced in this study so that the number of bins can be adjusted depending on computational resources available. Carbonaceous aerosols are divided into six categories according to their emission sources, each being characterized by a mode radius in the original version. In the size-resolved model, each category has its own size distribution which varies with space and time. For sulfate, aerosol microphysical processes (nucleation, condensation and coagulation processes) are represented with explicit size-dependency of the processes. The optical depths and mass budgets from the size-resolving version of the model are found to differ from the original version due to explicit representations of size

dependency of optical properties and physical process rates. The optical depths are also sensitive to alternate assumptions of size distribution of emitted dust. Comparisons with the original version also show a more distant transport of sulfate aerosols with the size-resolved distribution. These results suggest that size-resolving microphysics will lead to different estimates of aerosol forcing, and should be considered in global models in order to reduce the uncertainties of aerosol radiative forcing.

Seasonal Prediction of Indian Wintertime Aerosol Pollution using the Ocean “Memory” Effect

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Abstract:

As China makes every effort to control air pollution, India emerges as the world’s most polluted country, receiving worldwide attention with frequent winter haze extremes. In contrast with numerous studies linking haze in China with climate factors, the climate factors modulating Indian aerosol pollution have been less studied and are less understood. In this study, we decomposed the satellite observed historical spatial distribution of aerosol optical depth (AOD) over the 2003-2018 period, and found that the inter-annual variability of aerosol pollution over northern India is regulated mainly by a combination of El Niño and the Antarctic Oscillation (AAO). Both statistical analysis and numerical experiments using the Community Earth System Model version 2 (CESM 2) confirm that a strong El Niño condition excites a cyclone anomaly over northern India, reducing near surface wind speeds, thus aggravating aerosol pollution; positive AAO invigorates a meridional dipole sea surface temperature (SST) anomaly distributed over the Indian Ocean, and this feature enhances northerly winds over northcentral India, while weakening westerly winds over northeastern India, leading to a heterogeneous response in aerosol concentrations. Both El Niño SST anomalies and AAO induced Indian Ocean Meridional dipole SST anomalies can persist from autumn to winter, offering prospects for a prewinter forecast of wintertime aerosol pollution over

northern India. We constructed a multi-variable regression model incorporating El Niño and AAO indices for autumn to predict wintertime AOD. The prediction exhibits a high degree of consistency with observation, with a correlation coefficient of 0.78 ($p < 0.01$). This statistical model could allow the Indian government to forecast aerosol pollution conditions in winter, and accordingly improve plans for pollution control.

Classification of winter synoptic patterns in the northwest Sichuan Basin, China and their impacts on air quality

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Abstract:

Sichuan Basin, in southwestern China, is surrounded by high mountains such as Tibetan Plateau over west side. The interaction between the complex terrain and the synoptic patterns of the Tibetan Plateau is an important factor resulted in heavy air pollution in this area, especially during winter. However, the physical mechanism of this interaction on air quality is still unclear. In this study, nine synoptic patterns were identified by using the obliquely rotated principal component analysis of geopotential height 700 hPa over the Tibetan Plateau and Sichuan Basin, only for winter months from Dec 2013 to Feb 2017. These synoptic patterns can be classified into three categories based on the correlation between air quality and weather types: (1) low-trough patterns associated with heavy air pollution, (2) high-pressure patterns with medium air pollution, and (3) wet low-vortex patterns with relative low air pollution for all study days. The differences of physical mechanisms of these three categories' synoptic patterns can be utilized to explain the variations of local air quality. In the case of the low-trough pattern, the significant temperature gradient between the Sichuan Basin and the Tibetan Plateau, at the same level height, resulted in cold air from the Plateau moved eastward to the basin by the westerly airflow and induced a strong descending motion. A robust stable layer was formed above the PBL in the northwest Sichuan Basin due to subsidence warming; this phenomenon suppressed the vertical exchange of the atmosphere and caused shallow PBL. Therefore, this synoptic pattern is related to heavy air pollution, as the local secondary circulation was confined under the shallow PBL and air pollutant dispersion was restricted. To make matters worse, the low-trough pattern occurred most frequently among these three categories' synoptic patterns, accounting for 69.2% of the total winter days, indicating the improvement of air quality over there might face a great challenge. On the contrary, the cold air masses had invaded above the PBL in northwest of Sichuan Basin accompanied by the northerly flow of a high-pressure system or a wet low-vortex. Under this atmospheric condition, the atmospheric stability was significantly weakened, the second circulation was able to uplift above the PBL, and the PBL deepened, facilitating air pollutant dispersion. Additionally, a high frequency of precipitation, about 80%, was observed in wet low-vortex pattern, resulting in remarkable wet removal effects on air pollutants. The physical mechanism discrepancy of three synoptic patterns demonstrated that the air quality of Sichuan

Basin was significantly influenced by the complex terrain and atmospheric circulations. These results favor to develop a weather forecast-pollution potential warning system for the complex terrain areas of China.

Liquid-liquid phase separation in organic particles: importance of the average O:C

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Abstract:

Recently, experimental studies have shown that liquid-liquid phase separation (LLPS) in organic particles consisting of secondary organic materials generated in environmental chambers can occur even without inorganic salts. To obtain additional insight into LLPS in organic particles free of inorganic salts, we investigated LLPS in organic particles consisting of one and two commercially available organic species. For particles containing one organic species, three out of the six particle types studied underwent LLPS. In these cases, LLPS was observed when the O:C was smaller than 0.44 and the separation RH was between 97 and 100%. For particles containing two organic species, thirteen out of the fifteen particle types studied underwent LLPS. In these cases, LLPS was observed when the O:C was smaller than 0.58 and mostly when the RH was between ~ 90 and ~ 100% RH. In almost all cases for both one-component and two-component particles when LLPS was observed, the highest RH at which two liquids was observed was $100 \pm 2.0\%$. This indicates that these organic particles can affect the cloud condensation nuclei (CCN) properties. Results and implications from the studies will be presented.

Kinetics of Water Transport in Ultraviscous Organic Aerosol: Aerosol viscosity

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Abstract:

Ultraviscous and glassy aerosol particles have been recently reported to exist in the atmosphere. Ultraviscous and glassy states occur when a liquid is cooled or dried without nucleation and crystallization. Moreover, the viscosity of the liquid and aerosol increases exponentially during cooling and drying. Quantifying the interactions between ultraviscous or glassy aerosol particles and water vapour is crucial for understanding the formation of cloud condensation nuclei and ice nuclei in the atmosphere.

The purpose of this research is to measure the relative humidity dependence of the viscosity of proxy organic atmospheric aerosol and to determine the timescale for water transport to and from the particle. A range of organic compounds are considered as proxies for atmospheric secondary organic aerosol components. In order to measure the timescale of water transport and viscosity, individual aerosol droplets (3 - 6 μm) are captured using aerosol optical tweezers. The time-dependent size and refractive index of a trapped droplet is determined from the unique fingerprint of whispering gallery modes (WGMs) appearing in the cavity-enhanced Raman spectrum. As for many glassy systems, the dynamics of relaxation accompanying the change in water activity during a step across RH can be described by the Kohlrausch expression. Diffusivity of water is determined by the Fick's Second Law solved by partial differential equation model (the Fi_Pad model).

The viscosity is an important property to characterise to classify the phase behaviour of organic

Aerosols. The viscosity can be inferred from measurements of the binary coalescence process between two trapped aerosol particles using Holographic Optical Tweezers (HOT), covering a viscosity range of 12 orders of magnitude (10^{-3} to 10^9 Pa s). In this research, mainly aerosol viscosity, diffusion of water in organic-water mixture will be reported. The timescales of water transport during each evaporation and condensation step and the corresponding viscosity of the organic particle will be compared and the validity of the Stokes-Einstein equation relating viscosities and diffusion constants assessed.

Volatile or not? For HNO₃ from Mg(NO₃)₂ droplets- measurements by vacuum FTIR and aerosol optical tweezer

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Abstract:

Through directly absorbing and scattering solar light or indirectly serving as cloud nuclei, atmospheric aerosol particles have a significant influence on the earth climate. It is necessary to deeply investigate the hygroscopicity of aerosols, which is highly related to the aerosol composition, size, phase state and chemical reactivity. In the present study, the hygroscopicity of magnesium nitrate (Mg(NO₃)₂, MN) aerosols, a ubiquitous magnesium compound present in the atmosphere, were investigated by vacuum FTIR firstly. For new-made MN aerosols, the water content of aerosols decreased with the slow decrease of relative humidity (RH) from ~70% to ~20%, and the equilibrium of water between aerosols particles and gas phase was quickly attained. When RH pulses were performed on new-made MN aerosols, the partitioning equilibrium of water between MN aerosols and gas phase was also quickly attained without hysteresis. However, apparent hysteresis of aged MN aerosols (deposited on substrate for 7 hours after prepared) was observed during RH pulse process, suggested that more time was required for water partitioning equilibrium between the aerosols and gas phase. This phenomenon may be attributed to hydrolysis of the MN or volatile of HNO₃, and a film may form on the aged MN aerosols, leading to enhanced water mass transfer resistance. Moreover, the water diffusion coefficients of the new-made and aged MN aerosols were derived by using characteristic time calculated from KWW equation. The water diffusion coefficient of aged MN aerosols was $\sim 2.5 \times 10^{-13} \text{ m}^2 \text{ s}^{-1}$, which was about one magnitude lower than that of new-made MN aerosols ($\sim 3 \times 10^{-12} \text{ m}^2 \text{ s}^{-1}$). And the results of water diffusion coefficients agreed with the hygroscopicity of MN aerosols discussed above. Furthermore, the aged MN aerosols were further investigated by aerosol optical tweezer, which can levitate a single droplet and record stimulated Raman signals of the droplet. By fitting the whispering gallery mode with the Mie model, radius of the tweezered droplet can be determined. The droplet radius decreased with the decrease of RH, the radius under 70%RH, 60%RH, 50%RH, 40%RH, 30%RH was 7.20 μm , 6.80 μm , 6.25 μm , 5.70 μm , 5.55 μm , respectively. However, during the process of optical tweezer measurements, the droplet radius quickly responded to the decreased RH without hysteresis, which was contradictory with the results obtained from vacuum FTIR. This may be attributed to the difference between the two measurement methods. In the vacuum FTIR, the aerosols were deposited on the substrates and under low pressure, while the aerosol droplet tweezered by optical tweezer was

suspended and under ambient pressure. Since the uncertainties still exist, more efforts are needed for deeply understanding the hygroscopic behavior of the MN aerosols.

Primary and secondary surface-active organics are important Ice nucleating particles

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Abstract:

Increasingly concentration of organic materials has been found in the cloud ice residue in upper tropospheric cirrus clouds, stressing out their role in clouds formation and climate change. The surface-active organics were found in rain water and cloud droplets in various environments and different altitudes. As surfactant in atmospheric aerosols, Humic like substances (HULIS) originated from both primary emission of biomass burning and aqueous phase secondary organic formation account for a large fraction 60% of organic aerosols, while the ice nucleation efficiency of these organic materials is not well-recognized. In the present study, a recently developed optical droplet cooling array (PKU-INA) was used to measure the ice nucleating efficiency of HULIS aqueous droplets derived from ambient particulate matters and biomass burning particles in order to detect if HULIS can serve as INP in low-altitude mixed-phase clouds. In general, results showed that 1 μ l droplet containing HULIS (46.3 - 482.4 mg /L) frozen in the temperature range from -9°C to -25.9°C, which was above the pure water background and the typical homogenous freezing temperature (below -38°C). The ice nucleation active site density per unit mass nm(T) of HULIS was lower than that of one HULIS surrogate (SRFA), indicating different ice activity of organics derived from soil with that from ambient particles. HULIS treated by 0.45 μ m and 0.2 μ m filters keep its ice activity indicating that HULIS smaller than 200 nm could acting as ice nucleating particles and improve the freezing temperature of aqueous droplets.

Compared with large particles, these small HULIS particles has highly speculation to into and separate from particles or transport to higher altitude and large scales to have impact on the cloud formation.

A look at the formation of oxalate by single particle mass spectrometry

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Abstract:

With the measurements performed at a remote high-altitude mountain site, size-resolved mixing state of oxalate in cloud droplet residual (cloud RES), interstitial (cloud INT), and ambient (cloud-free) particles were firstly reported in south China. Our result demonstrates enhanced formation of oxalate in cloud, with ~15% of cloud RES and INT particles containing oxalate, in contrast to only 5% of cloud-free particles. This is the first direct evidence that majority of oxalate in the troposphere is formed from in-cloud aqueous pathway in China. Furthermore, individual particle analysis provides unique insight into the formation and evolution of oxalate during cloud formation in the free troposphere. Oxalate was predominantly (> 70% in number) internally mixed with the aged biomass burning particles. This is attributed to the abundance of organic acids associated with aged biomass burning particles, and thus was more favorable for the formation of oxalate. We show that in-cloud aqueous reaction improved the conversion of organic acids to oxalate. Since only limited information of oxalate is available in the free troposphere, the results also provide an important reference on future understanding of the abundance, properties, behavior, and climate impacts of oxalate. Second to biomass burning particle, oxalate was found to be internally mixed Fe-rich particles, which might influence the fate and impact of Fe in the regional environment. With additional observation performed in Guangzhou, We propose that Fe-involving chemistry improves the formation of the observed oxidized organics, and also the conversion of oxidized organics to oxalate. Aerosol water content should improve the Fenton chemistry when relative humidity is higher than 60%. The results on both the extent of internally mixed oxalate and Fe and the role of Fe on the oxalate formation would be used as references in modelling simulations to improve the understanding on the formation and fate of oxalate, and the evolution and climate impacts of particulate Fe.

Cloud chemistry and interaction with aerosols at a mountain site in Hong Kong

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Abstract:

Cloud/fog droplets play significant roles in the heterogeneous formation of secondary organic aerosol (SOA), but the multiphase processes are still poorly understood. Field measurements of cloud/fog water were conducted at Tai Mo Shan (TMS, 957 m a.s.l.) in Hong Kong during Oct-Nov 2016, to investigate the characteristics and sources of organic and inorganic species including dissolved organic carbon (DOC), carbonyls, organic acids (OA), water-soluble ions and trace metals. Acidic cloud/fog was observed with a volume-weighted mean (VWM) pH of 3.63, among which, sulfate (230 $\mu\text{eq L}^{-1}$) and nitrate (160 $\mu\text{eq L}^{-1}$) were the major contributors to cloud/fog water acidity, whereas the ammonium (133 $\mu\text{eq L}^{-1}$) was deficient to neutralization. The measured carbonyls and OA in the cloud water accounted for $18.5 \pm 10.4\%$ and $3.5 \pm 1.7\%$ of the abundant DOC (average of 12.9 mgC L^{-1}), respectively. Dilution and dissolution effects of cloud/fog parameters, liquid water content (LWC) and pH, on stable products such as DOC, OA, and water-soluble ions were well characterized by inverse power law functions. The partitioning of different carbonyl compounds between interstitial gas- and aqueous- phases were also examined with the advantages of simultaneous measurement in both phases. A significant aqueous-phase supersaturation with respect to the gas-phase concentrations of hydrophobic compounds (acetaldehyde and acetone with small Henry constants) was found. Whereas for more soluble glyoxal and formaldehyde, measured aqueous-phase concentrations were significantly below the theoretical equilibrium values, indicating important sink processes such as oxidation reactions exist in the aqueous phase. As a result of the cloud process, DOM mass fractions were found significantly increased for in-

cloud aerosols. This study provides valuable information on the in-cloud chemical processing of different species and the aerosol-cloud interactions in the subtropical and coastal region.

A novel method for calculating ambient aerosol liquid water content based on measurements of a humidified nephelometer system

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Abstract:

Water condensed on ambient aerosol particles plays significant roles in atmospheric environment, atmospheric chemistry and climate. Before now, no instruments were available for real-time monitoring of ambient aerosol liquid water contents (ALWC). In this paper, a novel method is proposed to calculate ambient ALWC based on measurements of a three-wavelength humidified nephelometer system, which measures aerosol light scattering coefficients and backscattering coefficients at three wavelengths under dry state and different relative humidity (RH) conditions, providing measurements of light scattering enhancement factor $f(\text{RH})$. The proposed ALWC calculation method includes two steps. The first step is the estimation of the dry state total volume concentration of ambient aerosol particles, V_a (dry), with a machine learning method called random forest model based on measurements of the “dry” nephelometer. The estimated V_a (dry) agrees well with the measured one. The second step is the estimation of the volume growth factor $V_g(\text{RH})$ of ambient aerosol particles due to water uptake, using $f(\text{RH})$ and Ångström exponent. The ALWC is calculated from the estimated V_a (dry) and $V_g(\text{RH})$. To validate the new method, the ambient ALWC calculated from measurements of the humidified nephelometer system during the Gucheng campaign was compared with ambient ALWC calculated from ISORROPIA thermodynamic model using aerosol chemistry data. A good agreement was achieved, with a slope and intercept of 1.14 and $-8.6 \text{ } [\mu\text{m}]^3 / [\text{cm}]^3$ ($r^2=0.92$), respectively. The advantage of this new method is that the ambient ALWC can be obtained solely based on measurements of a three-wavelength humidified nephelometer system, facilitating the real-time monitoring of the ambient ALWC and promoting the study of aerosol liquid water and its role in atmospheric chemistry, secondary aerosol formation and climate change.

Less than half of water-soluble organic matter contribute to hygroscopic growth: an application of 1-octanol-water extraction method

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Abstract:

The importance of water-soluble fraction of organic matter (WSOM) in atmospheric aerosol particles on the climate has widely been recognized since a quarter of century ago. WSOM can contribute to water uptake by aerosol particles, which eventually alters cloud formation processes and atmospheric radiation. In most of previous studies, WSOM was extracted by excess amount of water, suggesting that some of them might not contribute to water uptake process in the atmosphere. We have applied 1-octanol-water extraction method, which was recently developed for separating WSOM by polarity and water-solubility, to investigate hygroscopic properties of biomass burning particles. The method separates WSOM by 1-octanol-water-partitioning coefficient (KOW). KOW, which is known to correlate well with water solubility, has been used as a metric for polarity in the areas of environmental and pharmaceutical chemistry. The range of KOW following separation can be controlled by altering the volume ratio of 1-octanol and water. Biomass burning particles were generated in laboratory by combusting mosquito coil, Indonesian peat, and Indonesian vegetations (acacia and fern). WSOM extracted from these samples were analyzed using ultraviolet-visible absorption spectroscopy (UV-VIS), spectrofluorometer, time-of-flight aerosol chemical speciation monitor (ToF-ACSM), and hygroscopic tandem differential mobility analyzer (HTDMA). The positive matrix factorization (PMF) analysis was applied to the ToF-ACSM mass spectra, obtaining three categories of organic compounds for each types of biomass burning particles. Factor 1, which dominantly existed in the range of $\log KOW < 0$, was highly hydrophilic, as characterized by the intense signal at m/z 44. Factor 2 was marginally polar. Factor 3, which mainly distributed in $\log KOW > 1$, was dominated by hydrocarbons and high molecular weight species. The contributions of Factors 1, 2, and 3 in each types of biomass were 40-49%, 22-40%, and 17-30%, respectively. The UV-VIS and fluorescence analyses have demonstrated that Factor 1 was likely rich in light-absorbing humic-like substances (HULIS), while Factor 3 could include a high fraction of aromatic rings. The analyses have also suggested the existence of HULIS that have different polarities. Quantitative comparison of the PMF analysis with the HTDMA data revealed that Factor 1 dominantly contributed to hygroscopic growth of WSOM. On the other hand, Factors 2 and 3 were almost non-

hygroscopic. This result demonstrates that less than half of WSOM can contribute to hygroscopic growth, showing the importance of considering polarity in future studies on WSOM.

Temporal and spatial distribution of PM_{2.5} chemical components and their effects on atmospheric light extinction

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Abstract:

This study collected PM_{2.5} (aerodynamic diameters equal to or smaller than 2.5 μm) every six days at six sites in Taiwan in 2018. PM_{2.5} mass, water-soluble inorganic ions, and carbonaceous contents were resolved for further analysis.

The results showed that seasonal PM_{2.5} mass levels were the highest in winter and increased in the order from east (9 $\mu\text{g m}^{-3}$), north, to the south (40 $\mu\text{g m}^{-3}$) of Taiwan. Summer was the lowest season of PM_{2.5} mass at all sites. In general, SO₄²⁻ and organic carbon were the two most abundant components at all sites except NO₃⁻ at three southern sites in winter. The volatilizations of NO₃⁻ and Cl⁻ were the highest in summer and spring, respectively, while NH₄⁺ was relatively stable across seasons. Meanwhile, positive interferences of volatilized organic carbons adsorbed by quartz-fiber filters varied less than negative interferences from volatilization of the collected carbonaceous particles.

In resolving component ratios in PM_{2.5}, NO₃⁻ was the sole component increased greatly in high PM_{2.5} events ($\geq 35 \mu\text{g m}^{-3}$) which was consistent with the findings over the past three years. It implied that the control of precursor NO_x would help in reducing high PM_{2.5} events. Moreover, in comparing component ratios between events and non-events, the enhancements of NO₃⁻, both SO₄²⁻ and NO₃⁻, and SO₄²⁻ characterized local, regional, and transboundary pollutions, respectively. For source apportionment using positive matrix factorization, "sulfate and combustion emissions" and "nitrate and combustion emissions" were the two most significant factors at all sites. To estimate atmospheric light

extinction coefficient (b_{ext}), this study inserted PM_{2.5} chemical components, gas species, and relative humidity (RH) into the revised Interagency Monitoring of Protected Visual Environments (IMPROVE) equation. Sulfate contributed best the most of all components at all sites except nitrate at three southern sites in winter. SO₄²⁻ was also the most important factor in influencing atmospheric visibility from statistical regression analysis, which was consistent with the finding in the revised IMPROVE equation.

Given the fact that the distribution of PM_{2.5} mass concentration varies from the influences of local sources, pollution transport, and seasonal variations. In many scenarios, SO₄²⁻ is the most prominent PM_{2.5} chemical component, however, NO₃⁻ increased greatly when environmental ventilation is bad. Considering SO₂ is already low in the local areas, the control of NO_x from combustion sources may be a prioritized and effective job in reducing high PM_{2.5} events.

Vertical dependence of regional and local pollutants

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Abstract:

Pollutant concentrations within deep urban canopies are affected by regional and local sources. Little is known, however, about how the balance between them changes with height. In this study we use roadside measurements of particulates and numerical simulations with a high-resolution mesoscale model (WRF) and a building-resolving large-eddy simulation model (PALM) to determine the relative importance of regional and local sources. It is found that the crossover height from local to regional control depends sensitively on the building geometry. Implications for urban design are discussed.

Vertical Measurements of Black Carbon (BC) and Ozone (O₃) Using Miniature Devices Onboard an Unmanned Aerial Vehicle at A Suburban Site in Guangzhou, China

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Abstract:

Black carbon (BC) and ozone (O₃) are common atmospheric pollutants in urban areas. Many previous studies were mainly designed to measure the ground level concentrations of BC and O₃, but some other studies depicted the vertical profiles of BC and O₃ using meteorological tower, tethered balloon, and remote sensing techniques, but less attention is paid to the observation using unmanned aerial vehicles (UAV) that offers finer spatial resolution within lower troposphere^{3,4}. In this work, concentrations of both BC and O₃ were vertically measured at a suburban site in Guangzhou, China. In total, 102 flights were conducted between 27 October and 14 November 2018, of which 20 flights in the early morning (04 - 05 am), 22 in the morning (09 - 10 am), 28 in the afternoon (14 pm), 24 at nightfall (18 - 19 pm) and 8 at night (22 - 23 pm). In our measurements, ground-level (< 10 m) concentrations of BC and O₃ ranged from 1.6 ± 0.4 to 4.5 ± 0.7 $\mu\text{g}/\text{m}^3$ and 33.6 ± 10.2 to 88.1 ± 46.1 ppb, respectively. The value of Absorption Ångström Exponent (AAE) ranged from 0.8 ± 0.1 to 1.0 ± 0.2 . For the measurements under 500 m (relative height), O₃ increased while altitude increasing, while the reverse was true for BC; AAE increased slightly with height. The concentration of O₃ was always observed the highest during afternoon flights (101.6 ± 29.6 ppb), and the lowest in the early morning (34.5 ± 20.0 ppb), showing a significant diurnal pattern. The AAE value was usually lower at nighttime (0.8 ± 0.2) and higher at daytime (0.9 ± 0.2). These results might be attributed to (1) biomass burning from neighboring farmland during daytime (2) stronger mixing of local (newly emitted) and transboundary (aged) BC during daytime⁵. Besides, cluster analysis of 72-hour back trajectories suggested that the air mass transported from inland was more polluted than that from the coastal waters.

KEYWORDS: black carbon, ozone, vertical profile

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Data Quality Control System—the Key to Sensor Application in Air Quality Monitoring Network

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Abstract:

Low-cost air quality sensors have attracted increasing attention in recent years due to their advantages over conventional methods, such as low power requirements, easy installation, and deployability in large numbers to cover large spatial areas. However, they also face many technical challenges regarding data quality, including signal drift, temperature/humidity effect, cross interference, etc. To mitigate such issues and build a robust sensor-based system, a four-stage calibration quality control system is implemented, including standard material calibration, simulated environmental calibration, combined supervision calibration, and transfer calibration.

During standard material calibration, each individual sensor is screened for quality assurance by testing its response to known concentrations of standard gases of criteria air pollutants (SO₂, NO₂, CO, and O₃). Then, the selected sensors are assembled into “sensor node” to measure the multiple pollutants simultaneously. These sensor nodes are then put in a control chamber to perform simulated environmental calibration. Standard gases and particulate matters are injected into the chamber simultaneously to simulate a wide range of ambient conditions by controlling temperature and humidity. Machine learning and neural-networking algorithms are applied to characterize sensor response. Next, the sensor nodes are installed outdoor with a Federal Reference Method (FEM) monitor in close vicinity to conduct in-field combined supervision calibration. Since the real ambient atmosphere is more complicated than the controlled chamber conditions, the FEM data is used to train the algorithms for improved sensor response. In regions without FEM nearby, the transfer calibration is implemented using mobile or portable equipment to optimize the calibration parameters.

The result shows that (1) after standard material and simulated environmental calibration, the correlation between sensors and FEM measurements increased from 0.4-0.6 to over 0.95; (2) after adaptive learning through in-field combined supervision and/or transfer calibration, the correlation between sensor and FEM improved from 0.6-0.75 to over 0.85. Over 10,000 sensor nodes (over 60,000 single sensor) calibrated through this four-stage calibration system have been successfully deployed in

more than 80 cities across China and are currently being used in air quality monitoring for environmental management, research, and consulting. Recently, two sensors also show a steady performance during the wildfire season in the U.S.

KEYWORDS

Low-cost Air Quality Sensor, Air Quality Monitoring, Machine Learning Algorithm, Calibration System

Dynamic aerosol exposure risks of pedestrians during walking along the street canyon

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Abstract:

The traffic-generated particles inside street canyon will deteriorate pedestrian health by deposition in the lung. So it is of significance to investigate the particle transport process and evaluate human exposure risks in the street canyon. However, many previous researches neglected the influences associated with human walking which disturbs the airflow field near human body obviously. In this work, the Eulerian drift flux model combined with dynamic mesh approach is used to predict the particle transport and dynamic exposure risks of pedestrians during walking along the street canyon. A typical atmosphere velocity with 4m/s is applied and the corresponding mean velocity in the street is lower than 1m/s due to the blocking effect of flanking buildings. Besides, a large vortex is formed making the mean velocity at leeward and windward side is respectively about 0.4m/s and 0.9m/s. The human walking gesture has no conspicuous impact on the main flow but accelerates the air velocity near human body to nearly 1m/s. As a result of walking, a wake flow that possesses velocity about 1m/s will generate behind the human body. On the contrary, the moving body pushes the front air away leaving the air velocity smaller than 0.6m/s. This kind of flow field makes more particles accumulate in the front of the pedestrian and the human exposure risk elevates. It should be noted that only two pedestrians walking in opposite directions are considered in this study, the scenarios with sparse or dense crowd are not taken into account. We believed that the gaps between people in the crowd will aggravate exposure risks and this phenomenon will be studied in our future work.

The effect of vegetation barrier on the dispersion of ultrafine particles in a wind tunnel

Huy Ninh Xuan

Department of Environmental and Occupational Health, National Cheng Kung University, Taiwan

Andrey Khlystov, Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada, USA

Gabriel Katul, Nicholas School of the Environment, Duke University, Durham, North Carolina, USA

Chia-Ren Chu, Department of Civil Engineering, National Central University, Taiwan

Ming-Yeng Lin, Department of Environmental and Occupational Health, National Cheng Kung University, Taiwan

Abstract:

UFP in near roadway communities has recently gained significant attention due to their potential health risk. Charged particle from traffic emission contribute a significant portion of near roadway UFP. Vegetation barrier can alter the dispersion of UFP in near roadway environments. However, the effect of vegetation barrier on the dispersion of ultrafine particle (UFP) carrying different charges is still not well studied. In this study, we used a boundary layer wind tunnel to investigate the dispersion of UFP. A line source was used to simulate the traffic emission. We used one and two rows of model pine to simulate the vegetation barrier. Two different wind speed were tested (0.6 m/s and 1 m/s). We used a Tandem Differential Mobility Analyzer (TDMA) system to measure the dispersion of UFP carrying different charges at different points downwind of the line source. Preliminary results showed that the decay rate of charged particle are faster than neutral particle. Furthermore, two rows of vegetation are more effective at reducing the UFP number concentration than one row for both charged and neutral particle. The study result can benefit future urban planning and air quality models.

Inflow and outflow budget analysis of ambient particulate matter and trace gases in Delhi-NCR region of India

Sarkawt Hama

Univeristy of Surrey

Sarkawt Hama*, and Prashant Kumar

Global Centre for Clean Air Research (GCARE), Department of Civil and Environmental Engineering, Faculty of Engineering and Physical Sciences, University of Surrey, Guildford GU2 7XH, United Kingdom

Abstract:

Delhi was recently classified the most polluted city in the world for ambient air pollution by the WHO. The most prominent air pollutant is particulate matter (PM) which has great impact on human health. A key uncertainty in Delhi air quality controlling is the effect of emissions from the surrounding National Capital Region (NCR) upon the Delhi PM budget. This paper discusses an integrated study to obtain the spatiotemporal characteristics of particulate matter (PM₁₀ and PM_{2.5}) and trace gases (NO_x, O₃, SO₂, and CO) pollutants within a network of 12 air quality monitoring stations located over 2000 km² across Delhi-NCR for the years 2014–2017. The study aimed to determine inflow/outflow budget of PM pollution from NCR to Delhi and vice-versa, and to establish seasonal profiles of chemically active trace gases and pollution tracers in Delhi and to characterize the ‘background’ and “increment” concentrations of PM over the region. PM pollutant increments were determined through a combination of empirical methods such as Lenschow-type analysis, and k-means clustering. The annual and diurnal variations of each criteria pollutant were investigated by cluster analysis to evaluate current air pollution situations across the region. The concentrations of all pollutants during cold period (November-January) were significantly higher than those in other months with the exception of O₃, and the sites with the highest PM_{2.5} and PM₁₀ concentrations were located in central Delhi. The Kmeans clustering algorithm is applied to identify major source regions for PM_{2.5} and PM₁₀ in Delhi. Furthermore, the effect of metrological conditions on the PM will also be explored. This study is the first long term study to find the effect of inflow and outflow budget of PM acroases Delhi-NCR.

Acknowledgements

The ASAP-Delhi (An Integrated Study of Air Pollutant Sources in the Delhi NCR) is a joint UK-India project that has received funding from the Natural Environmental Research Council (NERC; NE/P016510/1), United Kingdom.

Overview of the National Strategic Project on PM_{2.5} Air Pollution in Korea

Gwi-Nam Bae

Korea Institute of Science and Technology

Abstract:

There has been growing concerns regarding PM_{2.5} (particulate matters <2.5 μm) nationwide in Korea since 2013 mainly due to the increased severe haze days in cold season. In addition, new findings of adverse health effect of PM and world reports regarding PM issues have been frequently open to public through media. Currently, PM_{2.5} air pollution is considered as one of important social issues to be solved urgently. It needs complicated scientific evidences and advanced technologies to implement public-sound environmental policies. Under this circumstance, a new national strategic project dealing with PM_{2.5} air pollution was launched in 2017. This project consisting of 15 sub-projects covers four major research fields such as characterization of haze phenomenon and its sources, forecast of air quality, development of advanced emission treatment technologies, and assessment of health effect and exposure management in living environments. In each field, two to five sub-projects are tightly linked to handle PM_{2.5} issues effectively. In addition, all sub-projects are connected and finally oriented toward same goal such as haze or exposure management policy based on scientific evidence and technical measures. This approach will be introduced to share our philosophy for PM_{2.5} management. Some outcomes will be discussed for heavy haze episodes, smog chamber experiments, Korean air quality forecast modeling system, promising selective catalytic reactor working at low temperature about 220 degree C, and association between PM_{2.5} exposure and health outcomes for sensitive populations.

Parallel Oral Session VI

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

30 May 2019 (Thursday) | 10:45 – 12:00

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Aerosol-climate-meteorology (3) Co-chair(s) Perapong Tekasakul, Prince of Songkla University	Linchang An, China Meteorological Administration (CAMS)	Analyses of temporal and spatial variations in sand and dust storm events in East Asia from 2007 to 2016	10:45-11:00	Mr and Mrs Lau Tat Chuen Lecture Theatre (LT-5)
	Perapong Tekasakul, Prince of Songkla University	Recent Haze Episodes in Southeast Asia and Effects to Ambient Aerosol in Southern Thailand	11:00-11:15	
	Siyu Chen, Lanzhou University	Influence of dynamic and thermal forcing on the meridional transport of Taklimakan Desert dust in spring and summer	11:15-11:30	
VOC and secondary precursors (2) Co-chair(s) 1. Sasho Gligorovski, Chinese Academy of Sciences 2. Tawatchai Charinpanitkul, Chulalongkorn University	Sasho Gligorovski, Chinese Academy of Sciences	Assessing the oxidation capacity of an indoor environment in Guangzhou, China	10:45-11:00	Chan Kei Biu Lecture Theatre (LT-6)
	Tawatchai Charinpanitkul, Chulalongkorn University	Removal of benzene contaminated in gas flow using low energy electron discharge method	11:00-11:15	
	Zhang Qian, Xi'an University of Architecture and Technology	Optical Features and Chemical Functional Groups of Winter Brown Carbon Aerosol between Northern and Southern China	11:15-11:30	
	Xiaorui Wu, NUS Environmental Research Institute (NERI)	Biomarkers Differentiating Terrestrial Plant Stress Response from Transboundary Biomass Burning Smoke in Urban Environment	11:30-11:45	
Urban aerosol and air quality (2) Co-chair(s) 1. Naoki Kaneyasu, National Institute of Advanced Industrial Science and Technology 2. Dan Jaffe, University of Washington	Ta-Chih Hsiao, National Taiwan University(<i>Invited Speaker</i>)	Relationship between Physicochemical Properties of Fine Particles and Visibility Impairment in Central Taiwan	10:45-11:15	SAE Magnetics Lecture Theatre (LT-9)
	Dan Jaffe, University of Washington	Use of a Generalized Additive Model to interpret PM2.5 and O3 trends, daily variations and impact of control measures for Chengdu and Beijing	11:15-11:30	
	Naoki Kaneyasu, National Institute of Advanced Industrial Science and Technology	Estimation of PM2.5 emission source in Tokyo Metropolitan area by simultaneous measurements of particle elements and oxidative ratio in air	11:30-11:45	
	Tengyu Liu, University of Toronto	Secondary Organic Aerosol Formation from Urban Roadside Air in Hong Kong	11:45-12:00	
Special symposium: Aerosol mass spectrometry (1) Co-chair(s) 1. Yele Sun, Chinese Academy of Sciences 2. Penglin Ye, Dilu Scientific Instrument	Yele Sun, Chinese Academy of Sciences (<i>KC Wong Foundation Invited Speaker</i>)	Aerosol Composition, Sources and Processes in Beijing: Insights from Long-term Measurements of Aerosol Mass Spectrometers	10:45-11:15	Peter Ho Lecture Theatre (LT-10)
	Penglin Ye, Dilu Scientific Instrument	Using AMS to determine the Vapor Wall Loss of Semi-Volatile Organic Compound in Smog Chamber	11:15-11:30	
	Yan Zheng, Peking University	Oxidative Aging and Secondary Organic Aerosol Formation of Fleet Vehicle Emissions	11:30-11:45	
	Jinjian Li, Hong Kong University of Science and Technology	Characterization of Aerosol Aging Potentials at Suburban Sites in Northern and Southern China Utilizing a Potential Aerosol Mass (Go:PAM) Reactor and HR-ToF-AMS	11:45-12:00	
Emission inventory (2) Co-chair(s) 1. Johannes Passig, University of Rostock 2. Rong Wang, Fudan University	Johannes Passig, University of Rostock	Remote Sensing of Ship Emissions by Single Particle Mass Spectrometry with Ionization Enhancement in Laser Desorption/Ionization	10:45-11:00	Leung Ko Yuk Tak Lecture Theatre (LT-14) 11:00-11:15
	Rong Wang, Fudan University	A global modeling of black carbon by updating the emission inventory and transport model	11:00-11:15	
	Jianbing Jin, Delft University of Technology	Dust storm emission inversion using multiple data sources over East Asia	11:15-11:30	
	Asta Gregoric, University of Nova Gorica	Determination of source specific black carbon and CO2 emission rates by means of 222Rn tracer	11:30-11:45	
	Jian Sun, Xian Jiaotong University	Characterization of PM2.5 source profiles from typical biomass burning of maize straw, wheat straw, wood branch, and their processed products (briquette and charcoal) in China	11:45-12:00	

Analyses of temporal and spatial variations in sand and dust storm events in East Asia from 2007 to 2016

Linchang An

China Meteorological Administration (CAMS)

Abstract:

We analyzed the frequency and intensity of sand and dust storms (SDSs) in East Asia from 2007 to 2016 using observational data from ground stations, numerical modeling, and vegetation indices obtained from both satellite and reanalysis data. The relationships of SDSs with surface conditions and the synoptic circulation pattern were also analyzed. The statistical analyses demonstrated that the number and intensity of SDS events recorded in spring during 2007 to 2016 showed a decreasing trend. The total number of spring SDSs decreased from at least ten events per year before 2011 to less than ten events per year after 2011. The overall average annual variation of the surface dust concentration in the main dust source regions decreased $33.24 \mu\text{g}/\text{m}^3$ (-1.75%) annually. The variation in the temperatures near and below the ground surface and the amount of precipitation and soil moisture all favored an improvement in vegetation coverage, which reduced the intensity and frequency of SDSs. The strong winds accompanying the influx of cold air from high latitudes showed a decreasing trend, leading to a decrease in the number of SDSs and playing a key role in the decadal decrease of SDSs. The decrease in the intensity of the polar vortex during study period was closely related to the decrease in the intensity and frequency of SDSs.

Recent Haze Episodes in Southeast Asia and Effects to Ambient Aerosol in Southern Thailand

Perapong Tekasakul

Department of Mechanical Engineering, Faculty of Engineering, Prince of Songkla University

Jiraporn Chomane, Department of Basic Science and Mathematics, Faculty of Science, Thaksin University

Surajit Tekasakul, Department of Chemistry, Faculty of Science, Prince of Songkla University

Masami Furuuchi, Graduate School of Natural Science and Technology, Kanazawa University

Abstract:

Recent haze episodes in Southeast Asia as a result of forest fires in Sumatra and Borneo islands affects many countries including Thailand. This research focuses on monitoring and analysis of polycyclic aromatic hydrocarbons (PAHs) associated with aerosol particles in the city of Hat Yai in southern Thailand from 2013-2017 to assess risk to human health. The most serious haze episode affecting southern Thailand was in 2015 with the largest number of hot-spot counts and atmospheric aerosol concentration well above the standard levels. This clearly affected health and daily life of people, and caused wide public awareness. Air samplings were conducted using a portable high-volume sampler, an Andersen air sampler equipped with inertial filter (ANIF) and a nanoparticle sampler (PM_{0.1} sampler). PAHs were analyzed using a high performance liquid chromatography (HPLC). The characteristics of ambient aerosol such as aerosol size distribution, aerosol concentration, aerosol-bound PAH concentration, and carcinogenic potency equivalent (BaP-TEQ) were investigated. Atmospheric aerosol size distributions in Hat Yai city shows bi-modal behavior with the major peak at 0.88 μm and MMAD of about 0.95 μm . The highest TSP and PAHs in 2015 were about 340.09 $\mu\text{g m}^{-3}$ and 47.65 ng m^{-3} , respectively. The total PAHs concentration varied from 4.32 to 47.67 ng m^{-3} . The maximum PAHs concentration is about ten times higher than that in non-haze periods. There were 5 period of haze transports to Thailand during August-October, 2015. Results of PAH analysis show a clear dominance of the large molecular compounds (4-6 aromatic rings) indicating a major source from biomass burning. This is in accordance with the hot-spot data in north Sumatra island, wind speed and direction, and precipitation condition. The transboundary haze transport from sources to southern Thailand generally took 1-2 days. Countries at the upstream of Thailand such as Singapore and Malaysia, as well as Indonesia were serious affected by the haze episodes.

Influence of dynamic and thermal forcing on the meridional transport of Taklimakan Desert dust in spring and summer

Siyu Chen

Lanzhou University

Jianping Huang

Abstract:

The Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) model associated with in-situ measurements and satellite retrievals was used to investigate the meridional transport of Taklimakan Desert dust, especially in summer. Both satellite observations and simulation reveal that TD dust particles accumulate over the Tibetan Plateau (TP) and the Tianshan Mountains in summer, resulting in higher dust concentration up to $85 \mu\text{g m}^{-3}$ here. The proportions of meridional transport of TD dust in summer increase up to 30 % of the total output dust over the TD. The impacts of thermal and dynamic forcing on the meridional transport of TD dust to the TP and Tianshan Mountains are investigated based on composite analysis and numerical modeling. It is found that the weakness of westerly jet over East Asia significantly decreases the eastward transport of TD dust. More TD dust particles lifted to higher altitude reach up to 8 km induced by the enhanced sensible heating in summer. Under the influence of the northerly airflow over the TD regions, the TD dust particles are strengthened southward transported to the northern slope of the TP through topographic forcing. Moreover, the cyclonic circulation raises dust particles to higher altitude over the TP. It can further intensify the TP heat source by direct radiative forcing of dust aerosols, which may have a positive feedback to the southward transport of TD dust. This research provides confidence for the investigation of the role of TP dust on radiation balance and hydrological cycle over East Asia.

Assessing the oxidation capacity of an indoor environment in Guangzhou, China

Sasho Gligorovski

Chinese Academy of Sciences

Majda Mekic, Chinese Academy of Sciences

Jiangping Liu, Chinese Academy of Sciences

Sheng Li, Chinese Academy of Sciences

Jiafa Zeng, Jinan University

Gwendal Loisel, Chinese Academy of Sciences

Wentao Zhou, Chinese Academy of Sciences

Chao Liu, Jinan University

Adrien Gandolfo, Aix Marseille University

Hartmut Herrmann, TROPOS

Zhujun Yu, Jinan University

Xue Li, Jinan University

Abstract:

Nitrous acid (HONO) is the most important precursor of the hydroxyl radical (OH), in the indoor atmosphere. Hence, the accurate quantification of HONO during daytime is of paramount importance regarding the OH radical concentrations and thus the oxidative capacity of the indoor atmosphere.

In this study time-resolved measurements of HONO, nitrogen oxides (NO_x) and ozone (O₃), in a real-life indoor environment in Guangzhou, China, were performed under two different conditions 1) in absence of any human activity and 2) in presence of cooking. We also determined the actinic flux of the sunlight in sunlit areas of the room during different periods of the day throughout the campaign.

The actinic flux was used to estimate the photolysis rates of NO₂ $J(\text{NO}_2)$ and HONO, $J(\text{HONO})$, which span in the range comparable to those corresponding to outdoor atmosphere. Based on the measured NO_x and HONO concentrations and using the $J(\text{NO}_2)$, and $J(\text{HONO})$ we applied the photostationary state approach (PSS) to estimate the OH concentrations in this particular indoor environment in Guangzhou.

The maximum OH concentrations were observed around noon, $1.5 \cdot 10^6 \text{ cm}^{-3}$ and $2.6 \cdot 10^6 \text{ cm}^{-3}$ in absence of human activity and during cooking, respectively.

The high concentration of OH radicals makes the indoor environment a reaction chamber, a fact which consequences remain to be explored hereafter.

Removal of benzene contaminated in gas flow using low energy electron discharge method

Tawatchai Charinpanitkul

Chulalongkorn University

Thanunwut Thanahirunthitichote, Weerawut Chaiwat, Komkrit Suttiponparnit,

Kyo-Seon Kim

Abstract:

Volatile organic compound (VOC) has been known as one of air pollutants generated from various human activities in metropolitan area and industrial processes. Among various technologies developed by research teams for handling and degrading such VOC, low energy electron discharge has been known as a novel and promising method because of its effectiveness and compactness. In this work, benzene, which was selected as a model VOC pollutant, was mixed with N₂ flow and supplied along the axial direction of stainless-wire electrodes which were connected to a high-voltage generator for activating corona discharge. Performance of a tubular reactor with low energy electron discharge for removal of benzene was experimentally examined with regard to stainless-wire electrode with diameter of 0.1, 0.3 and 0.6 mm, total gas flow rate in range 1,000 – 4,000 ml/min and initial concentration of benzene within a range of 500 – 2,000 ppm. It was found that larger electrodes for emitting low energy electrons could provide higher benzene removal efficiency due to the higher contact surface area. Meanwhile, an increase in the benzene removal efficiency at a lower gas flow rate would suggest that benzene removal would be regulated by the gas residence time.

Optical Features and Chemical Functional Groups of Winter Brown Carbon Aerosol between Northern and Southern China

ZHANG Qian

Xi'an University of Architecture and Technology

NING ZHI, Hong Kong University of Science and Technology

Abstract:

Brown carbon (BrC) play important roles in climate change through directly and semi-directly radiative forcing due to their strong light-absorbing properties at the near-ultraviolet and blue wavelengths. Advanced simulations and parallel experiments were also conducted between two geographically distinct cities-Xi'an and Hong Kong (abbreviate to XA and HK in later text) - in China during wintertime in 2016-2017 to predict the UV-visible absorption spectrum of different chemical structures of BrC in this study. In brief, the concentrations of PM_{2.5}, organic matter (OM), element carbon (EC) and three-major secondary inorganic aerosol species (NH₄⁺, NO₃⁻, and SO₄²⁻) showed higher levels in XA than those in HK, closely relating to heavy heating emissions and poor dispersion conditions (windspeed=2.3 m·s⁻¹) during the sampling days. The babs-370nm, BrC value and mean ratio of babs-370nm, BrC/babs-880nm, BC in XA were approximately 9 times higher than those in HK (12.6%), indicating that heavy burden of BrC was observed in XA while the major light absorber in HK was BC. Two peaks of diurnal variations of XA babs-370nm occurred during the periods of 7:00-11:00 and 19:00-00:00, which were coinciding with traffic, cooking/heating emissions. Meanwhile, high HK babs-370nm, BrC/babs-880nm, BC ratio was observed during the nighttime (1:00-4:00) also closely relating to secondary-BrC. Good correlations ($R > 0.7$, $P < 0.001$) among babs-365nm, BrC, water-soluble K⁺ and primary organic carbon (POC) were found in XA and HK. Unlike the high correlation coefficient of babs-365nm, BrC and secondary organic carbon (SOC) ($R = 0.73$, $P < 0.001$) in HK, the XA babs-365nm, BrC showed much poorer correlation with SOC ($R = 0.4$, $P < 0.001$). These phenomena emphasized that XA BrC mainly originates from primary combustion while the HK BrC were both influenced by primary and secondary sources in winter months. The FTIR spectra of XA BrC at 1653 cm⁻¹ showed the appearance of aromatic C-C stretching bands and C=O stretching of conjugated carbonyl group, representing fresh biomass burning. In contrast, the C=O absorbance often appears near 1730 cm⁻¹ in HK BrC particles emphasized the influence of photochemical reactions. This model predicted that the POA of biomass or wood burning showed slightly light absorptions once emitted. As for SOA, the UV absorption of isoprene SOA was also enhanced.

Biomarkers Differentiating Terrestrial Plant Stress Response from Transboundary Biomass Burning Smoke in Urban Environment

Xiaorui Wu

NUS Environmental Research Institute (NERI)

Abstract:

In response to abiotic and biotic stresses, terrestrial plants emit enhanced level of volatile organic compounds (VOC) that can be precursors of PM_{2.5}. One of challenges is to identify a suitable marker originating from biogenic emissions without interference of other sources and processes, such as photooxidation of biomass burning emissions. This study identifies response of terrestrial plants in a warm and humid urban environment intruded by transboundary peat-forest (PF) smoke in the Maritime Continent during 2011-2017. We quantified biogenic SOA, 2-methylglyceric acid (2-MGA) and 3-hydroxyglutaric acid (3-OHGuA), which are derived from photooxidation of biogenic VOC (BVOC, e.g. isoprene). We also analyzed a suite of fatty acids (C₁₆-24), and levoglucosan as well as its photooxidation intermediates to investigate their temporal correlation when the transboundary PF smoke dominantly affected the urban environment. Results show consistent increasing concentration trends in all the analyzed species when the PF smoke exerted a dominant influence during the smoke episode in 2013 and 2015. This suggests that the increased concentrations in biogenic-derived organics could result from the response of local plants to the smoke stress and/or oxidation of PF smoke compounds. To gather additional information, positive matrix factorization (PMF) incorporating 37 input elements of ~370 daily bulk PM_{2.5} samples is performed to explore the source contribution for individual compounds. Results show that 3-OHGuA and high molecular weight fatty acids (C_{≥19}) are mostly linked with both PF burning smoke and secondary aerosols. On the other hand, 2-MGA is mainly associated with local origins such as traffic emissions and road dust with less than detectable relevance with transboundary PF smoke. This suggests that 2-MGA is a better marker indicating the response of local vegetation to the smoke stress. Relative to non-smoke-dominant PM_{2.5} samples, the concentration of 2-MGA in smoke-dominant PM_{2.5} samples increased by factors of 2.6–3, demonstrating enriched emissions of BVOC in the urban environment when the PF smoke showed dominant influence on the urban environment.

Relationship between Physicochemical Properties of Fine Particles and Visibility Impairment in Central Taiwan

Ta-Chih Hsiao

National Taiwan University

Tang-Huang Lin, National Central University

Li-Hao Young, China Medical University

Ting-Hsuan Wang, National Central University

Jung-Chiu Chen, National Central University

Sih-Yu Chen, National Central University

Abstract:

Air quality in Central Taiwan has improved gradually over the past decade, though the visibility has not changed much. Visibility is related to air quality or more specifically the fine particulate matter (PM_{2.5}), however, not in a direct proportional relationship. With that in mind, this study evaluates the sources and formation mechanisms of PM_{2.5} to elucidate the likely causes to the aforementioned bottleneck in improving visibility. In this study, we set up a mobile atmospheric environment monitoring platform equipped with real-time instruments to observed near-surface aerosol physicochemical characteristics as well as optical properties in Taichung. The intensive measurements were conducted from September 2017 to October 2018. The highly time-resolved aerosol physicochemical properties are used for apportioning the contributions of sources and chemical-components on impaired visibility. The specific aims of this study are (1) to evaluate the relationships between air pollution sources and the chemical components of PM_{2.5}, (2) to characterize the roles of aerosol size distribution, cloud condensation nuclei, hygroscopic growth and optical properties in regional visibility, and (3) to analyze the impacts of urban developments on land cover changes, formation and emission of air pollutants, and the relationships among short-term weather changes, aerosol physicochemical properties and regional transport. Based on the 2017 observations, it was found that the sources of air pollutions in metropolitan area and in the western coast area in Central Taiwan(separated by Mountain Dadu) can be different. The extinction coefficient (k_{ext}) during the observation period is the highest in spring and the lowest in summer. The average of single-scattering albedo (SSA) is about 0.7. The increasing of aerosol extinction coefficients (corresponding to the visibility impairment) is highly depending on PM nitrate. Furthermore, particle size and the volatile components of PM can significantly influence the scattering efficiency per unit mass.

Use of a Generalized Additive Model to interpret PM_{2.5} and O₃ trends, daily variations and impact of control measures for Chengdu and Beijing

Dan Jaffe

University of Washington

Tang Ya, Sichuan University

Yingying Zeng, Sichuan University

Abstract:

Generalized Additive Models (GAMs) are flexible and powerful modeling tools to understand the relationship between air pollution, meteorology and emissions. GAMs can incorporate both quantitative, non-linear and categorical data, which makes them ideal tools to understand the complex relationships between air quality and meteorology. In this approach we train the model using meteorological data and trajectories to predict air pollutant concentrations. We have previously applied GAMs to understand the meteorological controls on ozone in 16 Chinese cities and found that the GAMs can explain 43-90% of the variance in daily maximum 8-hour average ozone (Gong et al 2018). In this work, we apply the GAM method to PM_{2.5} data from Chengdu and Beijing. Preliminary results for both show that the GAM can capture up to 70% of the variance in daily average PM_{2.5} concentrations. Key predictors are trajectory direction, wind speed and relative humidity. Similar to previous work, we find that PM concentrations in Beijing are substantially elevated when transport is from the southwest or southeast quadrants. Given that the model is overall unbiased in all seasons, we can use the GAM results to investigate the influence of control measures on PM_{2.5}. For example, during the 2015 “Parade Blue” time period (August 20-September 3, 2015), we find that emissions reductions during this period reduced the observed PM_{2.5} by 49%. We will also use this model to explore the relationship between daily variations in PM and O₃. This can help us understand the recent pattern in trends for both pollutants.

Estimation of PM_{2.5} emission source in Tokyo Metropolitan area by simultaneous measurements of particle elements and oxidative ratio in air

Naoki Kaneyasu

National Institute of Advanced Industrial Science and Technology, Japan

Shigeyuki Ishidoya, National Institute of Advanced Industrial Science and Technology, Japan

Yusuke Mizuno, Horiba Ltd.

Yukio Terao, National Institute for Environmental Studies, Japan

Hiroaki Kondo, National Institute of Advanced Industrial Science and Technology, Japan

Abstract:

To characterize the emission sources of PM_{2.5} that cause short-term severe air pollution events in the Tokyo Metropolitan area, Japan, contributing combustion sources were estimated by use of the oxidative ratio (OR) in air calculated from CO₂ and O₂ concentrations ($OR = -\Delta O_2 / \Delta CO_2$) and by elements in PM_{2.5} concurrently measured with an automated sampler equipped with a X-ray fluorescence analyzer and a beta-ray gauge (PX-375, HORIBA Ltd.). OR has been studied to differentiate the combustion sources of CO₂ measured in the atmosphere (Keeling, 1988). In the preliminary measurements, real-time analysis of PM_{2.5} sample spots by the X-ray fluorescence appeared to be practical for elements indexing soil dust particles and some elements characteristically emitted from combustion sources. The observation was conducted on a rooftop of a building (25m from the ground) at Yoyogi district located in the urban area of Tokyo. During a pollution event in October 8–12, 2017, increases in the concentration of PM_{2.5} were observed in the form of multiple waves. Among the concentration peaks of PM_{2.5}, 4-hour mean Pb/Fe ratios in PM_{2.5} were systematically high (0.06) in the 4th concentration peak of pollution compared to that in the 5th peak (0.02), suggesting that a lead enriched emission source, i.e., coal combustion, was dominant in the 4th peak of pollution waves. On the other hand, OR in air showed a sequential change in dominance of combustion sources; the 4th and 5th peaks of CO₂ had OR = 1.1 and 1.6, respectively. These values correspond to the typical OR emitted from coal combustion and petroleum fuel combustion, respectively. Results of element ratio in PM_{2.5} and OR in air were consistent for the difference in the 4th and 5th pollution waves, implying that OR in air can also be applicable to estimate the emission source of PM_{2.5}. In the presentation, the application of this method to early-winter pollution events that typically occur in the Tokyo Metropolitan area, Japan, will also be discussed.

Secondary Organic Aerosol Formation from Urban Roadside Air in Hong Kong

Tengyu Liu

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Liyuan Zhou, School of Energy and Environment, City University of Hong Kong, Hong Kong, China

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Dawen Yao, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Haoxian Lu, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China

Xiaopu Lyu, Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China

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Chak K. Chan, School of Energy and Environment, City University of Hong Kong, Hong Kong, China, City University of Hong Kong Shenzhen Research Institute, Shenzhen 518057, China*

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Abstract:

Motor vehicle emissions are an important but poorly constrained source of secondary organic aerosol (SOA). Here, we investigated in situ SOA formation from urban roadside air in Hong Kong during winter time using an oxidation flow reactor (OFR), with equivalent atmospheric oxidation ranging from several hours to several days. The campaign-average mass enhancement of OA, nitrate, sulfate, and ammonium upon OFR aging was 7.0, 7.2, 0.8, and 2.6 $\mu\text{g m}^{-3}$, respectively. To investigate the sources of SOA formation potential, we performed multilinear regression analysis between measured peak SOA concentrations from OFR and the concentrations of toluene that represent motor vehicle emissions and cooking OA from positive matrix factorization (PMF) analysis of ambient OA. Traffic-related SOA precursors contributed 92.3%, 92.4%, and 83.1% to the total SOA formation potential during morning rush hours, noon and early afternoon, and evening meal time, respectively. The SOA production factor (PF) was approximately 5.2 times of primary OA (POA) emission factor (EF) and the secondary particulate matter (PM) PF was approximately 2.6 times of primary particles EF. This study highlights the potential benefit of reducing secondary PM production from motor vehicle emissions in mitigating PM pollutions.

Aerosol Composition, Sources and Processes in Beijing: Insights from Long-term Measurements of Aerosol Mass Spectrometers

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Abstract:

Severe haze episodes frequently occur in the megacity of Beijing during the last decade, yet our knowledge on the sources, formation mechanisms and evolution of aerosol particles is far from complete. Here we present the results from multiple-year measurements that were conducted in urban Beijing from 2011 using an Aerosol Chemical Speciation Monitor and a High Resolution Aerosol Mass Spectrometer. The sources of organic aerosol (OA) have been fully characterized using positive matrix factorization and multilinear engine (ME2). The effects of photochemical and aqueous-phase processing on SOA composition, oxidation states, and evolution processes are characterized, and their roles in severe haze pollution are elucidated. In addition, the formation mechanism of secondary inorganic aerosol, particularly the heterogeneous hydroxymethanesulfonate (HMS) chemistry in winter haze periods will be presented. Finally, the vertical measurements that were conducted at different heights on a 325 m meteorological tower by using two aerosol mass spectrometers, and their insights into secondary aerosol formation will be discussed.

Using AMS to determine the Vapor Wall Loss of Semi-Volatile Organic Compound in Smog Chamber

Penglin Ye

Dilu Scientific Instrument

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Abstract:

We have investigated the vapor wall loss of semi-volatile organic compounds (SVOCs) in a Teflon smog chamber. We studied the vapor wall loss of seven SVOCs with known saturation concentrations, including alkanes (hexacosane, pentacosane, docosane, eicosane and d62-squalane), an organic acid (oleic acid), and a polyol (levoglucosan) in single-component and binary-component (organic) systems, using ammonium sulfate (AS) seeds to constrain the particle wall loss. We coated inorganic particles with SVOCs and measured the loss of organics from those particles to constrain the wall losses, observing loss rates proportional to the saturation concentrations of the SVOCs. The loss rate of oleic acid mixed with d62-squalane was proportional to its mole fraction in the mixture. Our results show that the vapor wall-loss rates of SVOCs are significant, quasi-irreversible, and proportional to the SVOC vapor concentrations. The vapor wall-loss rate constant of the SVOCs that we studied in the CMU chamber is $3.8 \pm 0.3 \text{ hr}^{-1}$; this is comparable to values in other chambers with similar surface area to volume ratios. Our results are also consistent with a relatively high mass accommodation coefficient for SVOCs, $\alpha_{\text{org}} > 0.1$.

Oxidative Aging and Secondary Organic Aerosol Formation of Fleet Vehicle Emissions

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Ying Liu, Peking University

Tong Zhu, Peking University

Yan Zheng, Peking University

Xi Cheng, Peking University

Tianjiao Jia, Peking University

Houhua Zhou, Peking University

Abstract:

Vehicle emissions in megacities contribute a large amount of gaseous precursors that can form secondary organic aerosol (SOA) via atmospheric oxidation. The contribution of SOA formation from vehicle exhaust to fine particulate matter remains unclear. Most of the current chemical transport models are unable to reproduce the magnitude and the variability of SOA mass in urban regions, suggesting large uncertainties in the emission inventories and/or in the SOA formation mechanism. For the transportation sector, it is important to investigate the SOA formation under real driving conditions of traffic fleets. We deployed a Potential Aerosol Mass (PAM) flow reactor in a mobile laboratory to investigate the in situ SOA formation from in-use motor vehicle emissions on the major roads in Beijing in the winter of 2018. A suite of instruments was equipped to measure the concentrations of traffic-related gaseous precursors and the chemical composition of fine particles, including gas analyzers, a proton transfer reactor mass spectrometer, and a time-of-flight aerosol chemical speciation monitor (TOF-ACSM) respectively. The hydroxyl radical concentration was set by the UV lamp strength in the PAM reactor to represent ~ 1 to 10 days of equivalent atmospheric oxidation. The optimum SOA production and the corresponding atmospheric equivalent exposure time were identified and were compared with other related studies. Potential contribution of mobile sources to fine-particle concentrations is estimated.

Characterization of Aerosol Aging Potentials at Suburban Sites in Northern and Southern China Utilizing a Potential Aerosol Mass (Go:PAM) Reactor and HR-ToF-AMS

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Abstract:

A high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) was connected after a Gothenburg Potential Aerosol Mass (Go:PAM) reactor to characterize changes of ambient aerosols before and after aging processes. We presented the first comparative measurements of the aging potentials of ambient aerosols in two suburban sites in Northern and Southern China (Changping District in Beijing, and Hong Kong). Before aging, non-refractory particulate matter $<1\ \mu\text{m}$ (NR-PM₁) in three sub-periods in CP averaged at 10.2–24.5 $\mu\text{g}/\text{m}^3$, and at 16.1–16.5 $\mu\text{g}/\text{m}^3$ in two sub-periods in HK. Organic aerosol (OA) dominated in NR-PM₁ for both CP (42–71%) and HK (43–61%). In CP, positive matrix factorization resolved five OA factors that are related to cooking (COA), biomass burning (BBOA), hydrocarbon-like (HOA), semi-volatile oxygenated (SVOOA), and low-volatility oxygenated (LVOOA). Instead, in HK primary OA (HOA+COA), SVOOA, and LVOOA were resolved. Secondary OA factors dominated the total OA for both CP (58–77%) and HK (62–83%). After aging, OA enhancement (78–98%) dominated the NR-PM₁ mass increment at both sites, while nitrate was enhanced the most among the inorganic species (7–9%). Aging led to more enhancements of SVOOA than of LVOOA (7.9 vs. 2.6 $\mu\text{g}/\text{m}^3$) in CP, while the reverse was true in HK (0.5 vs. 1.8 $\mu\text{g}/\text{m}^3$). More abundant locally emitted precursors in northern CP resulted in more “fresh” SVOOA after aging, while lack of gaseous precursors in southern HK resulted in more “aged” LVOOA, presumably from POA or SVOOA. This study reveals distinct aging characteristics of OA in suburbs in Northern and Southern China, which has implications for control policies on precursors of aerosols.

Remote Sensing of Ship Emissions by Single Particle Mass Spectrometry with Ionization Enhancement in Laser Desorption/Ionization

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Abstract:

Ships substantially contribute to global air pollution with serious impacts on climate and public health. Their emissions are associated with up to 400,000 annual deaths by cardiopulmonary diseases and lung cancer. Besides sulfur, large amounts of metals, soot, and organics are emitted, especially if low-grade bunker fuels are used. Mitigation strategies comprise the establishment of emission control areas. However, compliance is difficult to control due to a lack of techniques that facilitate emission monitoring at sea. We present a new method for remote sensing of ship emissions. The approach is based on a so far unknown enhancement effect in laser desorption/ionization that leads to substantially increased ion yields for particle-bound metals in single-particle mass spectrometry (SPMS). The proposed scenario comprises resonant light absorption by metal atoms and energy transfer in impurities

of air pollution particles. As a consequence, the sensitivity of SPMS instruments to these metals can be considerably improved by choosing the appropriate ionization laser wavelength. We demonstrate trace detection of vanadium in fresh particles from a ship engine exhaust, even many hours after switching from bunker fuel to diesel fuel. Applying the method for real-time analyses of ambient air at winds from the Baltic Sea reveal transient features of the aerosols vanadium content. These signatures were assigned to ship passages in up to 100 km distance using freely available data from air trajectories and ship automatic identification system (AIS). A coincidence between the particles vanadium and sulfur levels gives evidence to violations against the regulations in a central sulfur emission control area (SECA). Our findings will pave the way to a more sophisticated environmental monitoring and improved understanding of the serious global concern of air pollution, especially from ships. Besides opening new perspectives for environmental research, our study discloses an unexplored route of laser ionization with great potential for particle mass spectrometry.

A global modeling of black carbon by updating the emission inventory and transport model

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Fudan University

Yves Balkanski, LSCE

Olivier Boucher, LMD

Abstract:

Black carbon (BC) is an important short-lived climate forcer with significant impacts on climate and health. However, the direct radiative forcing (RF) of BC is subject to a large uncertainty, due to the limitations that models have to capture the observed light absorption. In this study, we investigated the effect of using highly disaggregated inventory and high-resolution model on modelling of BC radiation absorption. It's found that the low resolution in emission inventory and model is a significant and overlooked source of error in previous studies. Using a detailed 10-km emission inventory and a 50-km atmospheric model allows us to reduce the under-estimation of BC absorption by more than 50% over Asia. Downscaling the BC field to 10 km further reduces the bias to -5% in Asia. The underestimation of coarse-resolution models can be attributed to the fact that about half of the observational sites are located in locations within the top 90th percentile of BC AAOD. To reinforce these results, we applied a Bayesian method and obtain a best estimate of 0.37 Wm^{-2} , with a 90% uncertainty range of $0.11\text{-}0.83 \text{ Wm}^{-2}$. Our best estimate is lower than previously thought and, importantly, the uncertainty is reduced by 40%. This lower RF of BC implies that reducing BC emissions might improve air quality but bring less co-benefit for climate than expected.

Dust storm emission inversion using multiple data sources over East Asia

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Abstract:

Severe dust storms present great threats to the environment, property and human health over the areas in the downwind of arid regions. Several dusts forecast model have been developed for the prevention of impacts due to dusts. Currently, the accuracy of these models is limited by imperfect modeling of dust emissions. Data assimilation with available measurements could improve the emission through inverse modeling. However, emission inversion is usually challenging due to the huge computational cost of the assimilation algorithm, biases in the assimilated observations, and observation-simulation inconsistency. The remarkable progresses made in our study are the design of a dust emission inversion system which has a high computational efficiency, bias correction of PM10 measurements and data selection of satellite AODs as preprocessing before the assimilation.

Firstly, we developed an integrated dust storm forecast system - LOTOS-EUROS/Dust coupled with a reduced-tangent-linearization 4DVar data assimilation. Different from the traditional 4DVar which requires huge efforts to build and maintain the adjoint of realistic models, our assimilation algorithm is adjoint-free, and its computational complexity increases with the number of uncertain parameters. To further reduce the computation cost, a cascade of two model reducing techniques, sensitivity-based parameter filters and proper orthogonal decomposition have been implemented, which lead to a reduction of parameter dimension from initially $O(10^4)$ to $O(10^2)$.

Then, emission inversion is performed by assimilating PM10 measurements from an observing network constructed by China Ministry of Environmental Protection. However, data assimilation relies on a basic assumption of an unbiased observation error, while the PM10 measurements is actually a sum of the dust aerosols and the particles released in local activities that are considered as nontrivial biases. The importance of performing bias correction of PM10 measurements in dust emission inversion is illustrated. We innovatively adopted a data-based machine learning to model the non-dust composition in PM10. The dust assimilation was tested to be further improved by removing the bias from PM10 observations. While compared to the chemical transport model of non-dust PM10, the machine learning algorithm provides more accurate results in the bias correction.

Next, AODs from the new Himawari-8 satellite instrument are also assimilated. This advanced geostationary instrument is capable of monitoring the East Asian dust storms which usually have great spatiotemporal variability. Promising results are obtained in AOD assimilation experiments during an extreme dust storm event. However, some AODs show significant inconsistency with the simulations and the PM10 and AERONET observations, which might be caused by retrieval errors over a partially clouded scene. The assimilation procedure therefore includes a screening method to exclude those observations in order to avoid unrealistic results. A dust mask screening method is designed, which selects only those observations where the deterministic model produces a substantial amount of dust. This screening algorithm is tested to give more accurate result compared to the traditional method based on background covariance.

Determination of source specific black carbon and CO₂ emission rates by means of ²²²Rn tracer

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Abstract:

Black carbon is a component of fine particulate matter in the atmosphere which causes undesirable health outcomes [1] and significantly influences the climate [2]. It is produced by incomplete combustion of carbonaceous fuels, mainly fossil fuel and biomass. Black carbon concentration (BC) is thus a good indicator of primary emissions. However, atmospheric conditions play an important role in the magnitude and time evolution of ambient pollutants concentrations, which makes it difficult to reliably quantify the intensity of sources. On diurnal timescales, the planetary boundary layer (PBL) evolution significantly influences the variability of black carbon, as well as other primary gaseous pollutants, like CO₂. An alternative, recently used method for the assessment of PBL stability, is the use of naturally occurring noble radioactive gas radon (²²²Rn) [3]. Its diurnal variation is governed by the dispersion within the PBL and therefore represents a reliable tracer for near surface atmospheric conditions, allowing decoupling of meteorologically driven variation of primary pollutants from dynamics of the sources.

The aim of this study is to determine BC (apportioned to traffic and biomass burning sources) and CO₂ emission rate for two distinct locations in Slovenia (Europe), which differ from the point of view of their natural characteristics (geology, geomorphology, meteorology) and urban environment (urban and rural background), namely Ljubljana – the capital city and Vipava valley. Both locations are subjected to site specific pattern of air pollution episodes which are addressed and interpreted based on applied Eulerian box model. Effective mixing layer height was reproduced for both measurement locations based on Rn measurements, taking into account monthly resolved radon exhalation rate. Effective mixing height is used for decoupling meteorologically driven changes of measured concentrations from its source

related counterpart. Measurements of BC, CO₂ and Rn concentrations were conducted in the period from November 2016 to June 2017.

Although Vipava valley is significantly less populated compared to Ljubljana basin, BC concentrations reach similar level. We observed higher contribution of biomass burning sources in Vipava valley of 60 % compared to 32 % in Ljubljana. Hourly-resolved traffic emission rates, reproduced by the box model, show different diurnal pattern than concentrations - these are well correlated with traffic activity data. Higher biomass burning emission rates were observed in the afternoon and evening hours in winter and experience significant dependence on air temperature, which was observed at both locations. Determination of CO₂ emission rates allows us to estimate average black carbon emission factors characteristic for both locations.

[1] WHO (2012) Health effects of Black Carbon. The WHO European Centre for Environment and Health: Bonn.

[2] Bond, T. C., et al (2013) *J. Geophys. Res. - Atmos.* 118(11), 5380–5552.

[3] Chambers, S. D., et al (2015) *Atmos. Chem. Phys.* 15(3), 1175–1190.

Characterization of PM_{2.5} source profiles from typical biomass burning of maize straw, wheat straw, wood branch, and their processed products (briquette and charcoal) in China

Jian SUN

Xian Jiaotong University

Jian SUN, Xian Jiaotong University

Zhenxing SHEN, Xian Jiaotong University

Abstract:

Chemical profiles from burning of raw biomass materials (i.e., maize straw, wheat straw and wood branch) and their processed products (i.e., briquette and charcoal) were determined with a customized cleaning stove in a combustion chamber. Inorganic species such as water-soluble ions and elements, and carbonaceous fractions including saccharide and polycyclic aromatic hydrocarbons (PAHs) in fine particulate matter (PM_{2.5}) were quantified. Organic carbon (OC) was the highest fraction with a mass contribution to PM_{2.5} ranged from $17.65 \pm 0.15\%$ to $40.17 \pm 3.83\%$. Potassium (K⁺) and chloride (Cl⁻) were the two most abundant water-soluble ions ($4.31 \pm 1.57\%$ and $3.05 \pm 1.29\%$, respectively). Most elements (e.g., heavy metals) had relatively low composition (<0.01%) or below detection limit. For organics, levoglucosan averagedly accounted for over 60% in total quantified saccharides, while 4-rings PAHs was the most dominant fraction. The compositions of OC, sum of quantified PAHs (\sum PAHs) and levoglucosan, as well as diagnostic ratios such as OC/element carbon (EC), K⁺/EC, and sum of quantified saccharides (\sum saccharides)/PM_{2.5} showed a characteristic descending order of raw fuels > briquette > charcoal. In comparison, charcoal burning had lower compositions of the organics since most volatile matters and moisture had been removed during carbonization. In addition, the similarities of chemical profiles from different bio-fuels burning were accessed by calculating the coefficient of divergence (CD) and their correlations. Relatively low CD (0.21-0.36) and high correlation ($R > 0.97$) suggest that the chemical profiles from straw and their briquettes were similar. However, the profiles from charcoal burning showed significant differences between their corresponding raw fuels (CDs=0.26-0.47, $R = 0.69 \sim 0.99$) and also large variations from each other (CDs=0.40-0.49, $R < 0.90$). The results of this study summarize that the processed fuels especially charcoals are unique in source apportionment and inventory studies.

Parallel Oral Session VII

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

30 May 2019 (Thursday) | 13:30 – 15:30

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
Nanoparticles and nanotechnology (1) Co-chair(s) 1. Masaru Kubo, Hiroshima University 2. De-Hao Tsai, National Tsing Hua University	Masaru Kubo, Hiroshima University	Effects of nanoparticle properties on the structure of nanoparticle agglomerates generated by spray-drying of suspension of monodisperse nanoparticles	13:30-13:45	Mr and Mrs Lau Tai Chuen Lecture Theatre (LT-5)
	De-Hao Tsai, National Tsing Hua University	Metal-organic frameworks and gas-phase encapsulation of CuO nanocrystals for highly active catalysis	13:45-14:00	
	Tomoyuki Hirano, Hiroshima University	Rapid and Energy Effective Production of Cs Doped Tungsten Oxide Nanoparticles in a Flame Aerosol Reactor for Near-infrared Shielding Applications	14:00-14:15	
	Qiao Xin Gao	Study on filtration performance of nanoparticle coated electrostatic filters	14:15-14:30	
	Dianping Jiang, Hiroshima University	Visible-Light Photoactivity of Photocatalytic Ag-TiO ₂ Nanocomposite Thin Film Prepared via Combined Gas-phase Deposition of Nanoparticles	14:30-14:45	
	Gedi Mainelis, Rutgers University	Evaluation of Nanoparticle Resuspension and Resulting Exposures due to the Use of Consumer Nanosprays	14:45-15:00	
	Dae Hoon Park, Yonsei University	Plug-and-Play Safe-by-Design Production of Magnesium Oxide (MgO) Nanoparticles for Safer Antimicrobial Activity	15:00-15:15	
	Heedong Jang, Korea Institute of Geoscience and Mineral Resources	Aerosol Synthesis of Iron-Cobalt Oxides Nanoparticles Loaded Crumpled Graphene Composite for Supercapacitors	15:15-15:30	
Urban aerosol and air quality (3) Co-chair(s) 1. Hwajin Kim, Korea Institute of Science and Technology (Invited Speaker) 2. Jay Turner, Washington University in St. Louis	Hwajin Kim, Korea Institute of Science and Technology (Invited Speaker)	Chemical composition, sources and formation process of submicron aerosols in Seoul Metropolitan area during summer: Comparison to winter	13:30-14:00	Chan Kei Bui Lecture Theatre (LT-6)
	Min Hu, Peking University	Secondary Chemical Formation Enhanced PM _{2.5} and Haze Pollution in the Fall and Winter of North China	14:00-14:15	
	Kazuichi Hayakawa, Kanazawa University	Change of Polycyclic Aromatic Hydrocarbons Pollution in the Far-Eastern Asia	14:15-14:30	
	Wei Zhou, Institute of Atmospheric Physics	Characterization and source apportionment of organic aerosol at 260m on a meteorological tower in Beijing, China	14:30-14:45	
	Jun He, University of Nottingham Ningbo China	Effect of Radical Emission Control on Submicron Aerosol Pollution during 2016 G20 Summit in Hangzhou	14:45-15:00	
	Laura-Helena Rivellini, National University of Singapore	Characterization of carbonaceous aerosols in urban: Insight of carbon ions and trace metals from a Soot-Particle Aerosol Mass Spectrometer	15:00-15:15	
Aerosol chemistry (5) Co-chair(s) 1. Xiaohong Yao, Ocean university of China 2. Ru-Jin Huang, Chinese Academy of Sciences	Judith Chow, Desert Research Institute	Measuring and Using Brown Carbon for Source Apportionment, Visibility, and Climate Assessment	13:30-13:45	SAE Magnetics Lecture Theatre (LT-9)
	Nethmi Kasthuriarachchi, National University of Singapore	Strongly absorbing primary and secondary brown carbon in an urban environment	13:45-14:00	
	Yunfei Wu, Chinese Academy of Sciences	A study of the morphology and effective density of externally mixed black carbon aerosols in ambient air using a size-resolved single-particle soot photometer (SP2)	14:00-14:15	
	Weijun Li, Zhejiang University	Direct Observations of Fine Primary Particles From Residential Coal Burning: Insights Into Their Morphology, Composition, and Hygroscopicity	14:15-14:30	

	Tianyi Tan, Peking University	Impacts of Emission Source and Aging Process on Black Carbon Size Distribution and Mixing State: Implications for Climate Effects of Black Carbon	14:30-14:45	
	Tiantian Wang, Peking University	Mixing states of the black carbon in the East China and its associated source	14:45-15:00	
	Martin Rigler, Aerosol d.o.o., R&D Dept., Ljubljana, Slovenia.	HIGH TIME RESOLUTION MEASUREMENT AND SOURCE APPORTIONMENT OF TC, BC and OC, EC	15:00-15:15	
Special symposium: Aerosol mass spectrometry (2)	Mikinori Kuwata, Nanyang Technological University (<i>Invited Speaker</i>)	Dominant contribution of oxygenated organic aerosol to haze particles from real-time observation in Singapore during an Indonesian wildfire event in 2015	13:30-14:00	Peter Ho Lecture Theatre (LT-10)
Co-chair(s) 1. Xinlei Ge, Nanjing University of Information Science and Technology 2. Dandan Huang, Shanghai Academy of Environmental Sciences	Xinlei Ge, Nanjing University of Information Science and Technology	Chemical and optical properties of BC-containing particles in urban and remote sites of China	14:00-14:15	
	Alex K. Y. Lee, National University of Singapore (<i>Invited Speaker</i>)	Influences of primary emission and secondary coating formation on the mixing state of black carbon-containing particles	14:15-14:45	
	Dandan Huang, Shanghai Academy of Environmental Sciences	Formation and evolution of aqSOA from aqueous-phase reactions of phenolic carbonyls: comparison between ammonium sulfate and ammonium nitrate solutions	14:45-15:00	
	Yanfeng Chen, Nanjing University of Information Science and Technology	Seasonal light absorption properties of water-soluble brown carbon in atmospheric fine particles in Nanjing, China	15:00-15:15	
	Douglas Worsnop, University of Helsinki	Atmospheric Aerosol Chemistry: Climate and Air Quality	15:15-15:30	
Aerosol instrumentation (1)	Se-Jin Yook, Hanyang University (<i>Invited Speaker</i>)	Development of a double-shrouded probe for particle sampling in high-velocity flows	13:30-14:00	Jennifer and Haywood Cheung Lecture Theatre (LT-13)
Co-chair(s) 1. Da-Ren Chen, Virginia Commonwealth University 2. Juha Kangasluoma, University of Helsinki	Da-Ren Chen, Virginia Commonwealth University	A Cost-effective, Surface Area Sensor for PM Surface Area Concentration Monitoring	14:00-14:15	
	Yoshio Otani, Kanazawa University	Measurement of particle size distribution of high-concentration aerosols with centrifugal filter	14:15-14:30	
	Xue Li, Jinan University	Development of a high performance single particle mass spectrometer	14:30-14:45	
	Weiwei Hu, University of Colorado at Boulder	An overview on evaluation of the new capture vaporizer for Aerosol Mass Spectrometers (AMS)	14:45-15:00	
	Ralf Zimmermann, Rostock University	A New Multiple-Ionization Single Particle Aerosol Mass Spectrometer: Rapid On-line Analysis of Toxic Polycyclic Aromatic Hydrocarbons (PAH), Metals (Pb, Zn etc.) as well as Anionic Source Marker Compounds on Individual Airborne Aerosol Particles	15:00-15:15	
	Juha Kangasluoma, University of Helsinki	Improving the accuracy and precision of sub-3 nm nanoparticle measurements	15:15-15:30	
Filter and control technology (1)	Ki Joon Heo, Korea Institute of Industrial Technology	Effectiveness of automotive cabin air filters to protect passengers against air pollution during a life cycle.	13:30-13:45	Leung Ko Yuk Tak Lecture Theatre (LT-14)
Co-chair(s) 1. Fengxian Fan, University of Shanghai for Science and Technology 2. De-Qiang Chang, Northeastern University, China	Li-Yi Li, National Taiwan University	The Study of Filtration Characteristics of Ultra-Fine Fibers Filter Produced by Electrospinning	13:45-14:00	
	De-Qiang Chang, Northeastern University, China	Factors Affecting Particle Depositions on Electret Filters Used in Residential HVAC Systems and Indoor Air Cleaners	14:00-14:15	
	Fengxian Fan, University of Shanghai for Science and Technology	Numerical investigation of evolution of aerosol size distribution under combined effect of heterogeneous condensation and acoustic agglomeration	14:15-14:30	
	Yu-Chao Wang, National Taipei University of Technology	Enhancing the Efficiency of Flat-plate Electrostatic Precipitator by a Unipolar Ion Jet Generator	14:30-14:45	

	Ting-Lung Chen	Effective extension of the electrostatic filter media lifetime with Thermoplastic Polyurethanes	14:45-15:00	
	Kang-San Lee, Korea Institute of Energy Research	Particulate removal characteristics of pilot scale two stage vortex wet scrubber system	15:00-15:15	
	Hyunwook Cho, Inha University	The effect of filter outside air-blowing cleaning on the fabric filter contaminated by submicron particle	15:15-15:30	

Effects of nanoparticle properties on the structure of nanoparticle agglomerates generated by spray-drying of suspension of monodisperse nanoparticles

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Abstract:

Spray-drying is a method to obtain solid particles by spraying a solution or suspension of particles followed by drying. This method is widely used in many fields such as the pharmaceutical industry, food processing, and materials processing. For materials processing, the spray-drying of a nanoparticle suspension is expected to utilize the properties of nanoparticles because the generated nanoparticle agglomerates have higher porosity compared to nanoparticle powder obtained by simple drying. Meanwhile, the spray-drying method is utilized in an inhalation test to assess the toxicity of nanoparticles to human health. This is because the method can generate nanoparticle aerosols with constant particle size of approximately 100 nm and constant mass concentration in air. We conducted the inhalation tests using five nanoparticles with different compositions and primary particle sizes [1-4]. These studies revealed that the mass concentration of aerosols is proportional to the mass concentration in suspension, while the relationship between aerosol particle size and the characteristics of nanoparticles in suspension (mass concentration and primary particle size) is still unclear.

In this study, we investigated the effects of the primary particle size and mass concentration of nanoparticle suspension on the structure of nanoparticle agglomerates generated by spray-drying of monodisperse SiO₂ nanoparticle (MSN) suspension.

MSNs with primary particle size D_p of 20, 40, 60, 80, and 100 nm were synthesized. The mass concentration of suspension C_s was increased from 0.625 to 10 mg/mL. The spray-drying of the suspension was carried out using the experimental setup reported in our previous study.

The aerosol particle size of nanoparticle agglomerates measured by a scanning mobility particle sizer was proportional to C_s to the power of 1/8 at constant D_p , and D_p to the power of 1/4 at constant C_s . As one droplet is converted into one particle, the particle consists of nanoparticles included in the droplet. If the nanoparticles were assembled into a close-packed structure, then the aerosol particle size will be proportional to C_s to the power of 1/3 and does not depend on D_p . However, the results were different from this assumption, which is attributed to the difference in the packing structure of agglomerates. From electron microscopy observations, the agglomerates had a nearly close-packed structure when D_p

was small or C_s was high. On the other hand, when D_p was large or C_s was low, the agglomerates had a randomly-packed structure. Nitrogen adsorption measurements revealed that the pore volume of nanoparticle agglomerates increased with increasing D_p and decreasing C_s , i.e., decrease in the number of nanoparticles in a droplet. Therefore, the number of nanoparticles in a droplet controls the porosity of nanoparticle agglomerates that affect the aerosol particle size and morphology.

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Metal-organic frameworks and gas-phase encapsulation of CuO nanocrystals for highly active catalysis

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Abstract:

A new, facile aerosol-based approach is demonstrated for characterizing thermal stability of metal-organic frameworks (MOF) useful for the fabrication of MOF-based hybrid nanostructure directly in gas phase. The structural thermal stability of MOF was developed using a temperature-programmed electrospray-differential mobility analysis (TP-ES-DMA). Results show that MOFs are thermally decomposed via simultaneous dis-assembly and de-aggregation at a specific high temperature of decomposition (T_d), which depends on both the metal node and organic linker of MOF. Using a refined gas-phase evaporation-induced self-assembly approach, copper oxide nanoparticles are successfully encapsulated in the porous structure of UiO-66 to form a hybrid mesoporous nanostructure. CO oxidation is chosen as the model reaction, showing that the synthesized CuO@UiO-66 has a very high catalytic activity and stability comparing to the bare CuO nanoparticle samples. Our work demonstrates the first study of determining the temperature suitable for the fabrication of MOF-based hybrid nanostructure using an in-situ aerosol-based measurement method. The prototype method proposed in this study also provides an effective route of evaluation of thermal stability of MOF and their hybrid nanostructure for a variety of heterogeneous catalytic applications.

Rapid and Energy Effective Production of Cs Doped Tungsten Oxide Nanoparticles in a Flame Aerosol Reactor for Near-infrared Shielding Applications

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Abstract:

There has been a strong demand for shielding near-infrared (NIR) radiation from solar energy for solar control windows to reduce energy consumption of air conditioning and thereby decrease the emission of carbon dioxide.

Cesium doped tungsten oxide ($\text{Cs}_{0.32}\text{WO}_3$) nanoparticles has been regarded as highly promising NIR shielding material. Until now, $\text{Cs}_{0.32}\text{WO}_3$ nanoparticles have been synthesized via solid state, hydrothermal, water controlled-release solvothermal, and thermal plasma synthesis methods that need high energy, costs, or long time. Thus, it is necessary to synthesize $\text{Cs}_{0.32}\text{WO}_3$ nanoparticles using a rapid and energy effective method to make it feasible for large-scale and practical applications.

A flame-assisted spray pyrolysis (FASP) is an aerosol process that shows great promise as a process for continuous production of nanoparticles at high rate and enables us to control the particle size, crystal size, and morphology of nanoparticles by controlling fuel and carrier gas flow rates, concentrations of precursor, and so on.

In this work, highly crystalline and hexagonal single-phase $\text{Cs}_{0.32}\text{WO}_3$ nanoparticles were successfully synthesized by FASP followed by annealing under a reducing gas atmosphere (5% H_2/Ar). The as-synthesized nanoparticles from FASP indicated multiple phases of hexagonal $\text{Cs}_{0.32}\text{WO}_3$ and cubic $\text{CsW}_1.6\text{O}_6$. However, after annealing at 650°C for 1 h under a reducing gas atmosphere, the crystal structure of the $\text{Cs}_{0.32}\text{WO}_3$ nanoparticles changed completely to a single hexagonal $\text{Cs}_{0.32}\text{WO}_3$ phase. To characterize their optical performance, the as-synthesized $\text{Cs}_{0.32}\text{WO}_3$ nanoparticles were dispersed in methyl isobutyl ketone at a concentration of 0.02 wt%. The $\text{Cs}_{0.32}\text{WO}_3$ nanoparticles prepared in this research showed a remarkable near-infrared shielding ability with a 97.7% cut-off at 1500 nm. Unlike conventional methods, the proposed process in this research has several advantages, including a short reaction time and the ability to yield products with high purity and good energy efficiency, in particular the use of a grinding process was avoided. Although grinding processes have been widely used in industrial processes, it remains difficult to control the particle size precisely by this approach. Furthermore, the surface of the nanoparticles can be damaged, and there is a possibility of

contamination during the grinding process. Conversely, our suggested process can be used to prepare highly crystalline nanoparticles without contamination. It is easy to scale up and has the potential to rapidly prepare nanoparticles within several minutes. In conclusion, FASP shows great promise as a new method for rapid and energy effective production of Cs_{0.32}WO₃ nanoparticles that exhibit absorption in the near-infrared region without the need for a grinding process.

Study on filtration performance of nanoparticle coated electrostatic filters

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Abstract:

The mechanism of air filtration can be divided into four major methods, including inertial impact, interception, gravitational settling and diffusion. However, the combined filtration efficiency decreases in the region between 100 nm to 400 nm. It was found that the electrostatic force of an electrostatic filter can be used to enhance the filtration efficiency in this region. However, captured oil mist can significantly decrease the stored electrostatic charges on the electrostatic filter and can rapidly decrease its filtration efficiency.

In this paper, we report our study on coating nanoparticles on a polypropylene electrostatic filter to enhance its filtration performance for the application of oil mist filtration. A standard polypropylene (PP) electrostatic filter with fiber diameter ranging from 100 nm to 450 nm was used. SiO₂ and PTFE nanoparticles with dimension less than 100 nm was sprayed and flowed into the PP filter. This method of surface treatment was based on using an atomizer to generate 40.1 nm to 732.6 nm aerosols containing nanoparticles. Once these aerosols attached to PP fibers, solvents were evaporated and leaving nanoparticles coated on the fiber surface, where these nanoparticles were randomly coated. Thus, nanoparticles can be used to minimize oil spreading and masking PP fibers. To study the influence of nanoparticles, different amount of nanoparticle coatings was studied. Furthermore electrostatic surface potential of treated PP filters also was studied, and it was found that its value was higher than non-treated PP filters. Finally, it also was demonstrated that the surface characteristics of the charged polypropylene filter can be changed after nanoparticle treatment, and the performance of treated PP filters in high concentration oil mists will also be presented and discussed.

Visible-Light Photoactivity of Photocatalytic Ag–TiO₂ Nanocomposite Thin Film Prepared via Combined Gas-phase Deposition of Nanoparticles

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Abstract:

In recent years, effective visible light-activated photocatalysts have attracted considerable attention for water and air purification. The presence of noble metal (such as Ag, Au, and Pt) nanoparticles (NPs) in the TiO₂ matrix causes excellent photocatalytic activity because of the localized surface plasmon resonance (SPR) effect produced by noble metal NPs and electron-hole pair separation promoted by the metal-semiconductor junction. The SPR, which is produced by the collective oscillations of surface electrons by light irradiation, can dramatically amplify the absorption of visible light. Furthermore, the metal-semiconductor junction on the interface between the noble metal and TiO₂ leads to the photogenerated electron transfer to the TiO₂ matrix, which enhances the photocatalytic activity of noble metal-TiO₂ nanocomposites.

For the preparation of Ag-TiO₂ nanocomposites, various routes, which can be categorized as liquid methods, have been approached. However, fabrication techniques involving the liquid methods have disadvantages such as large number of processing steps, need for high temperatures under vacuum conditions, and requirement of impurity removal techniques. In this study, Ag-TiO₂ nanocomposite thin films on a silicon substrate were synthesized in the gas phase by a combination of plasma-enhanced chemical vapor deposition (PECVD) and physical vapor deposition (PVD) techniques. The detailed procedure of the synthesis is described in the literature [1]. In short, TiO₂ and Ag NPs generated by the PECVD and PVD systems, respectively, are mixed uniformly in the gas phase and deposited on the substrate to form the Ag-TiO₂ nanocomposite thin film with subsequent heat treatment. The Ag concentration in the prepared films was adjusted by changing the amount of Ag vapor in the PVD system.

The effects of the Ag concentration on the crystallinity, morphology, visible light absorption, and visible photocatalytic activity of the fabricated nanocomposite films were investigated by X-ray diffraction spectroscopy, X-ray photoelectron spectroscopy, transmission electron microscopy, and UV-vis diffuse reflectance spectroscopy. All the samples comprised the anatase phase of TiO₂, and metallic Ag NPs (~ 4

nm) were confirmed to be uniformly dispersed in the TiO₂ matrix. The visible light absorption of the synthesized thin film was obviously enhanced by the presence of Ag nanoparticles. The photocatalytic activity measured by evaluating the degradation of the Rhodamine 6G aqueous solution under visible light irradiation showed that the Ag-TiO₂ nanocomposite thin film with 2.4 wt% Ag concentration exhibited the highest photocatalytic performance. This study will be important in the preparation of not only Ag-TiO₂ nanocomposite films but also metal-semiconductor nanocomposite films, which have significant potential applications in photocatalysis, solar energy conversion, antibacterial application, and construction of chemical sensors.

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Evaluation of Nanoparticle Resuspension and Resulting Exposures due to the Use of Consumer Nanosprays

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Abstract:

The popularity of nanotechnology-based consumer products continues to increase. At the same time, use of such products as consumer sprays may result in direct and indirect inhalation exposures. This study examined deposition, resuspension, and potential exposures when nano-enabled sprays are used in a home.

The examined exposure scenarios included adults walking and young children crawling on the floor (breathing zone close to the floor). The latter was simulated by a robotic crawler. Two Ag-containing and two Zn-containing spray products were selected based on our earlier studies. The products were applied in a 5 x 9 x 8 ft³ chamber with controlled background particle concentration. The experiments were performed with carpet and vinyl flooring. Each product was sprayed for 5 min, and particles were allowed to settle on the floor. The particles were resuspended by an adult walking or a robot crawling for 10 minutes every 24 h to determine if resuspension changes over time. Resuspension rate and particle size distributions were measured statically at 0.3 m and 1.1 m above the floor, as well as with a mobile instrument which measured particles in the experimenter's breathing zone during spraying and resuspension. Filter samples were also collected to analyze the morphology and chemical composition of the resuspended particles.

The sprayed particle mass concentration in the breathing zone ranged from 2.33×10 to $8.67 \times 10^3 \mu\text{g}/\text{m}^3$, and the floor-deposited mass density (loading) ranged from 2.31×10^3 to $1.04 \times 10^7 \mu\text{g}/\text{m}^2$. The resuspended particle concentration in the breathing zone ranged from 1.21×10^2 to $8.33 \times 10^3 \mu\text{g}/\text{m}^3$ during walking and from 2.41 to $4.96 \times 10^2 \mu\text{g}/\text{m}^3$ during robot crawling, depending on the product and floor type. We found that the resuspension rate ranged from 5.93×10^{-5} to $3.49 \times 10^{-1} \text{h}^{-1}$ and reached a peak value after 24 h for vinyl flooring and after 48 h - 96 h for carpet. As could be expected, the large particles representing agglomerates of nanosprays contributed the most to the resuspended particle mass concentration, and small particles were the main contributors to the resuspended particle number concentration. Interestingly, the resuspension rate from the carpet was an order of magnitude higher than that from the vinyl while walking, but only 1.5x higher than that from the vinyl with the robot crawling. Also, the resuspension rate from walking was an order of magnitude higher than that from the robot crawling for both floor types. The resuspended particles and their

agglomerates showed the presence of various metals, including Ag and Zn as was advertised in product composition.

Our study shows that when nanotechnology-enabled spray consumer products are used in homes, the sprayed particles not only deposit, but they can also be resuspended from flooring and become available for inhalation exposure. The extent of the resuspension depends on the flooring type, the product, as well as the activity causing the resuspension.

This work was supported by the US Consumer Product Safety Commission, contract CPSC-S-16-0057.

Plug-and-Play Safe-by-Design Production of Magnesium Oxide (MgO) Nanoparticles for Safer Antimicrobial Activity

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Abstract:

Designing functional nanomaterials to reduce their hazard to human health and environment has become important, and on-demand production is also receiving much recent attention to meet unpredictable demands of modification and reconstruction to achieve the maximum efficacy of materials processing in the field of nanoscience and technology. These approaches could be applied to antimicrobial nanomaterials, because they require built-to-order configurations with safe-by-design principles for practical applications. However, not many studies have attempted to reduce toxicity with original material function using efficiently practical production platforms. To address these technological shortcomings, we developed a safe-by-design plug-and-play approach for continuous gas flow production of magnesium oxide (MgO) nanoparticles with safer antimicrobial activity. On-demand synthesis of MgO nanoparticles was conducted from single-pass aerosol-based process under gas flow conditions. MgO nanoparticles that have various oxidation rates were generated by changing O₂ ratio in gas flow conditions using spark ablation system. Then, the minimal inhibitory concentration (MIC) values and in vitro cytotoxicity of MgO nanoparticles against both Gram-positive bacteria (*S. epidermidis*) and Gram-negative bacteria (*E. coli*) were evaluated. Using this approach, we achieved precise modulation of oxidation rates in nanoparticles without using batch hydrothermal chemistry and a novel platform to constantly fabricate nanoparticles which have safer antimicrobial activity without significant cytotoxic effects.

Aerosol Synthesis of Iron-Cobalt Oxides Nanoparticles Loaded Crumpled Graphene Composite for Supercapacitors

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Abstract:

Supercapacitors have attracted widespread research interest as an important energy storage device due to their long cycle life, high power densities, and fast recharge capability. The performance of supercapacitors is largely determined by the properties of the electrode materials. Mixed transition metal oxides (MTMOs) have been explored as attractive electrode materials for supercapacitors owing to their higher electronic conductivity and larger specific capacitance compared with simple transition metal oxides. In this study, we present three-dimensional (3D) crumpled graphene (CGR) decorated with Fe-Co oxide nanoparticles to determine which molar ratio of Fe/Co can exhibit higher electrochemical supercapacitor performance. The CGR/iron-cobalt oxide composites were synthesized in different molar ratios of Fe/Co from iron (III) nitrate hexahydrate and cobalt (II) nitrate hexahydrate, respectively, via aerosol spray pyrolysis. Sizes of Fe-Co oxides nanoparticles ranged from 5 to 10 nm when loaded onto 500 nm CGR. The CGR/Fe-Co oxide electrodes fabricated at the Fe/Co ratio of 0.1 showed the highest performances in the capacitance and electrical conductivity among those electrodes with different molar ratios of Co/Fe.

Chemical composition, sources and formation process of submicron aerosols in Seoul Metropolitan area during summer: Comparison to winter

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Abstract:

To investigate the seasonal characteristics of submicron aerosol (PM₁) in urban areas of Korea, chemical composition, and temporal and diurnal variations of PM₁ were investigated using an HR-ToF-AMS in the Seoul Metropolitan Area (SMA) during summer. Also the characteristics and dynamic variations of organic aerosol (OA) sources and processes were investigated using positive matrix factorization (PMF) and the results were compared to the one in winter.

In summer, the average concentration of PM₁ was 19.1 $\mu\text{g m}^{-3}$, which was composed of 49% organics, 28% SO₄, 7% NO₃, and 9% NH₄. Organics had an average O/C ratio of 0.46 and an average OM/OC ratio of 1.79. Eight distinct sources of OA were identified via PMF analysis of the HR-ToF-AMS data: hydrocarbon like OA (HOA), cooking OA (COA), nitrate OA (NO₃-OA), sulfate OA (SO₄-OA), low volatile oxidized OA (LV-OOA), semi volatile oxidized OA (SV-OOA), nitrogen enriched OA (NOA) and organo-sulfate and -nitrate related OA (OS-ON-OA). Among all OA factors, 80% was secondary and only 20% was the primary OA.

Our results indicate that the average concentration and composition of PM₁ measured in SMA during summer were significantly different from those measured during winter. For instance, compared to winter, the average PM₁ concentration was lower during summer (19.1 vs. 27.5 $\mu\text{g m}^{-3}$), the mass fraction of sulfate was higher (28 vs. 10 %) but that of nitrate was lower (7 vs. 24 %). Together with lower SO₂ in summer (4.3 vs 6.9 ppb), likely due to less coal combustion for heating, higher sulfate concentration (5.4 vs 2.9 $\mu\text{g m}^{-3}$) indicate the more efficient conversion of SO₂ to sulfate under stronger solar radiation (0.95 vs 0.66 MJ/m²) or more regional transport of sulfate. Furthermore, PMF analysis indicate that about 20% of sulfate during summer is in organic combined. In terms of OA, OA was more oxidized (O/C ratios; 0.46 vs 0.37) and more different types of SOA sources (6 vs 2) were observed, composing higher SOA fraction than the one in winter (80 vs 41%). One reason for this is the intensive photochemical formation occurred in summer showing the better ($r=0.65$ vs 0.47) and higher daytime OOA/Ox ratios (0.17 vs 0.12). Also impact of POA was less significant in summer because there was not wood burning OA (BBOA). Finally, COA and HOA are the important POA source throughout the year, but contribute less (20 vs 36%) during summer. These results indicate that air quality in SMA

reflect the differences between the two seasons in meteorological conditions and emissions and formation processes of air pollutants.

Secondary Chemical Formation Enhanced PM_{2.5} and Haze Pollution in the Fall and Winter of North China

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Abstract:

Severe PM_{2.5} and haze pollution in the fall and winter of North China has been concerned. Our previous studies demonstrated a periodic cycle of PM episodes in Beijing and surrounding areas, which is governed by meteorological conditions. Simultaneous intensive field measurements were conducted in the winter of 2017 in two sites of urban Beijing and regional Dezhou in Shandong Province. Particle number concentrations (down to 1.5 nm), gas precursors (such as SO₂, NO_x, VOCs, sulphuric acid, NH₃, amine, and HOMs), aerosol chemical compositions and optical properties were measured.

Totally four pollution episodes were observed. Two of them were developed from new particle formation (NPF) and growth to haze. Sulphuric acid, NH₃, amine, and HOMs are potential precursors for the NPF event. The new particles acted as the seeds in the atmosphere and sequent growth with contribution of secondary organic aerosols and secondary inorganic ions. The MALTE-box model was adopted to discuss the nucleation formation.

The other two episodes were coupled with regional transport and local emission and secondary formation. After strict coal combustion control in recent years both SO₂ and sulfate in PM_{2.5} were decrease obviously. Nitrate and organics in PM_{2.5} became dominant components. Gas phase and aqueous phase formation of nitrate and organics and their control factors were discussed.

Change of Polycyclic Aromatic Hydrocarbons Pollution in the Far-Eastern Asia

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Abstract:

The combustion of fossil fuels and biomass produces polycyclic aromatic hydrocarbons (PAHs) and nitropolycyclic aromatic hydrocarbons (NPAHs). In urban air, fine particulate matter (PM_{2.5}) contains large amounts of PAHs and NPAHs. Benzo[a]pyrene (BaP), as a representative PAH, is classified as a Group 1 compound (carcinogenic to humans), while dibenz[a,h]anthracene, 6-nitrochrysene and 1-nitropyrene (1-NP) are classified as Group 2A (probably carcinogenic to humans). Moreover, 1,3-, 1,6-, 1,8-dinitropyrenes and 1-NP show strong direct-acting mutagenicity. Recently, the WHO classified outdoor air pollution, as well as PM_{2.5} into Group 1 [1]. Furthermore, several PAHs and NPAHs show endocrine-disrupting and reactive oxygen species-producing activities [2, 3].

To understand recent urban pollution in Far-Eastern Asia, PM was collected in the summer and winter of 9 cities in Japan, China, Korea and Far-Eastern Russia between 1997 and 2014. PAHs and NPAHs were respectively determined using HPLC systems with fluorescence and chemiluminescence detectors [4, 5].

As results, atmospheric concentrations of PAHs and NPAHs were still much higher in China (especially during the winter in northern cities) and Russia, while the concentrations decreased significantly in Japanese commercial cities. In China, several cities showed BaP concentrations higher than the ambient air quality level (1 ng m⁻³). The smaller [NPAH]/[PAH] ratios of Northern-Chinese and Far-Eastern Russian cities showed that major contributors were coal winter heating, while the larger [NPAH]/[PAH] ratios at the beginning of Japanese commercial cities showed that major contributors were automobiles. The significant decrease of the ratio in the Japanese cities suggested the effective countermeasures against PM/NO_x emissions from automobiles. However, concentrations of PAHs in iron manufacturing cities have not decreased significantly [6]. From these results, the future atmospheric pollution of this context will be discussed.

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Characterization and source apportionment of organic aerosol at 260m on a meteorological tower in Beijing, China

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Abstract:

Despite extensive efforts toward the characterization of submicron aerosols at ground level in the megacity of Beijing, our understanding of aerosol sources and processes at high altitudes remains low. Here we conducted a 3-month real-time measurement of non-refractory submicron aerosol (NR-PM₁) species at a height of 260 m from 10 October 2014 to 18 January 2015 using an aerosol chemical speciation monitor. Our results showed a significant change in aerosol composition from the non-heating period (NHP) to the heating period (HP). Organics and chloride showed clear increases during HP due to coal combustion emissions, while nitrate showed substantial decreases from 28 to 15–18%. We also found that NR-PM₁ species in the heating season can have average mass differences of 30–44% under similar emission sources yet different meteorological conditions. Multi-linear engine 2 (ME-2) using three primary organic aerosol (OA) factors as constraints, i.e., fossil-fuel-related OA (FFOA) dominantly from coal combustion emissions, cooking OA (COA), and biomass burning OA (BBOA) resolved from ground high-resolution aerosol mass spectrometer measurements, was applied to OA mass spectra of ACSM. Two types of secondary OA (SOA) that were well correlated with nitrate and chloride–CO, respectively, were identified. SOA played a dominant role in OA during all periods at 260 m although the contributions were decreased from 72% during NHP to 58–64% during HP. The SOA composition also changed significantly from NHP to HP. While the contribution of oxygenated OA (OOA) was decreased from 56–63 to 32–40%, less oxidized OOA (LO-OOA) showed a large increase from 9–16 to 24–26%. COA contributed a considerable fraction of OA at high altitude, and the contribution was relatively similar across different periods (10–13%). In contrast, FFOA showed a large increase during HP due to the influences of coal combustion emissions. We also observed very different OA composition between ground level and 260 m. Particularly, the contributions of COA and BBOA at the ground site were nearly twice those at 260 m, while SOA at 260 m was ~15–34% higher than that at ground level. Bivariate polar plots and back-trajectory analysis further illustrated the different source regions of OA factors in different seasons.

Effect of Radical Emission Control on Submicron Aerosol Pollution during 2016 G20 Summit in Hangzhou

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Abstract:

In order to evaluate the effects of radical air pollution control measures implemented throughout the G20 summit (held on 4th-5th Sept 2016) in Hangzhou, a field sampling campaign was undertaken before (15th Aug-23rd Aug), during (24th Aug-6th Sept) and after (7th Sept-26th Sept) control periods excluding those days with sporadic rain events in Hangzhou. Daily PM_{2.5} samples were collected, in which water soluble inorganic ions, trace metals and PAHs were analyzed. The local government phased in the emission control strategy by three stages in Hangzhou, including a power plant operational capacity reduction (50%) from 24th Aug to 6th Sept (phase I), followed by "odd-even" on-road vehicle restriction (i.e. 50% vehicle emission reduction) from 28th Aug to 6th Sept (phase II) and industrial VOC reduction from industrial sectors (e.g. refinery and chemical processes/facilities) from 31st Aug to 6th Sept (phase III). The average daily concentrations of abovementioned PM_{2.5} and its chemical components were showing a consistently incremental trend from pre-control, during control, to post-control periods. Interestingly, from 31st Aug to 3rd Sept, much higher PM_{2.5} concentrations were observed than the rest control period from 4th-6th Sept, possibly indicating there was a delayed effect of the radical emission control measures. Particularly, during the control period excluding 31st Aug to 3rd Sept, all PM_{2.5} and its chemical components presented lower occurrence levels than both pre- and post-control periods. In addition, co-located online measurement of PM₁ and particle size distribution ranging from 3nm to 750 nm was also conducted concurrently. The control measures in phase I had suppressed the growth of particles and decreased PM₁ by 40% and 58% compared to those before and after the control period. Sub-10 nm nanoparticle concentrations declined by 48% and 42% in morning and evening rush hours, respectively, after the implementation of 50% on-road vehicle reduction in phase II. The control measures enforced in phase 3 resulted in a 53% reduction of PM_{0.1} concentration. However, the WRF-Chem simulation suggested that local emissions within the control region still contributed more than 70% to PM₁ in Hangzhou even under the strictest control scheme.

Characterization of carbonaceous aerosols in urban: Insight of carbon ions and trace metals from a Soot- Particle Aerosol Mass Spectrometer

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Abstract:

Atmospheric carbonaceous aerosol consists of black carbon (BC) and organic aerosol (OA) which can lead to significant impacts on air quality, human health and climate. Understanding the sources and the atmospheric processes that can influence the physio-chemical properties of carbonaceous aerosol are essential to evaluate their impacts. In the last two decades, real-time aerosol mass spectrometry has been used worldwide to characterize and apportion various types of primary and secondary OA (POA and SOA). It is well-known that BC can be co-emitted with POA from combustion sources, and SOA can mix with combustion emissions in the atmosphere and even formed on BC surface through oxidation of gas-phase precursors and POA. However, the relative importance of individual BC source and how BC interact with OA during chemical aging remains largely unexplored.

With the recent development of soot-particle aerosol mass spectrometer (SP-AMS), OA and refractory BC (rBC) can be characterized and quantified simultaneously that makes the highly-time resolved source apportionment of rBC with OA possible. In this study, a SP-AMS was first deployed in Singapore, a highly urbanised city in the Southeast Asia. By integrating rBC fragments (C1+–C9+) to our positive matrix factorization analysis, five types of OA with different rBC mass fraction were identified. We provide evidence that two fuel combustion-related OA, referred to as hydrocarbon-like OA (HOA) and oxidized-HOA (O-HOA), and the less-oxidised oxygenated OA (LO-OOA) that represents the fresh SOA produced via local photochemistry are the major contributors to the total rBC (~20-43% for each factor). In contrast, cooking-related OA (COA) and the more-oxidised OOA (MO-OOA) that represents the aged SOA component were composed of low rBC content, accounting for ~8% of total rBC.

Furthermore, we demonstrate that the C1+/C3+ ratio and refractory metals detected by the SP-AMS, can be used as indicators to separate rBC sources. In particular, our results suggest that the rBC transported from industrial area and shipping ports gave higher C1+/C3+ ratios than the rBC associated with local traffic (i.e., C1+/C3+ ratio of O-HOA and LO-OOA > HOA). The V:Ni ratio evidences a clear

diurnal cycle with higher values encountered during day time, which appears to be transported alongside LO-OOA. Lastly, other trace metals - such as Na, K and Rb - and their potential association will be discussed to help identifying the origin of different sources.

Measuring and Using Brown Carbon for Source Apportionment, Visibility, and Climate Assessment

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Abstract:

Black carbon (BC) and brown carbon (BrC) aerosols are light-absorbing substances that affect the Earth's radiative balance. While BC absorbs light across the visible spectrum, BrC primarily absorbs light at wavelengths less than 500 nm. It is becoming widely recognized that aerosols that absorb light are not limited to black soot particles, often termed BC. Smoldering biomass burning and some secondary organic compounds also absorb light at shorter wavelengths, giving rise to the term BrC. BrC is a simplification, as these particles may also appear to be yellow, green and even purple when sampled on filters. There are also non-carbonaceous particles, especially from windblown dust, that non-uniformly absorb light at different wavelengths. Instruments that have been used to measure the multiwavelength absorption include: 1) photoacoustic spectrometers; 2) seven wavelength aethalometers; 3) UV-VIS spectrometers with and without integrating spheres applied to integrated filter samples; and 4) multiwavelength thermal/optical carbon analyses that adds a temperature/evaporation dimension to aerosol absorption characteristics. Absorption spectra are qualitatively similar for these techniques, although the absolute absorptions differ. Causes of these differences are: 1) divergent measurement principles; 2) biases owing to aerosol deposits and filter media; and 3) ad hoc calibration standards. Establishing primary standards, such as the Spectralon coatings used to calibrate detectors on NASA satellites, represents a first step toward comparability among the methods being used by a larger number of researchers.

BrC is being measured in U.S. chemical speciation networks and in those of other countries using a thermal/optical carbon analyzer with seven wavelengths ranging from 405 to 980 nm. Outputs include estimates of aerosol absorption and charring corrections at each wavelength. A power-law fit through the light attenuation spectra yields the Absorption Ångström Exponent (AAE). BrC light absorption is estimated by subtracting the BC contribution with an AAE of 1 for each of the shorter wavelengths. Multiwavelength thermal/optical carbon measurements from the U.S. Interagency Monitoring of PROtected Visual Environments (IMPROVE) and Chemical Speciation Network (CSN) (~300 sites) for 2016-2018 (~100,000 samples) to better understand the abundances and temporal variation of BrC in

carbonaceous aerosols. It is shown that the analyses maintain continuity with the long-term OC and EC databases for these networks. On average, non-urban IMPROVE samples show higher fractional BrC absorption than urban CSN samples, owing to greater influence from biomass burning and aged aerosols, as well as to higher primary BC contributions from engine exhaust at urban sites. The AAEs are higher at the IMPROVE than at the CSN sites. Sequential samples taken during an Everglades National Park wildfire illustrate the evolution from flaming to smoldering, with the BrC fraction increasing as smoldering begins to dominate the fire event. Characterization of light absorption properties of laboratory-generated BrC surrogate compounds demonstrate the feasibility of using surrogate compounds' mass absorption efficiencies to convert BrC light attenuation to equivalent BrC mass concentrations.

Strongly absorbing primary and secondary brown carbon in an urban environment

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Abstract:

Light absorbing organic aerosols (OA), commonly referred to as brown carbon (BrC), can have significant impacts on aerosol photochemistry and climate. While biomass burning is one of the major sources of atmospheric BrC, there are limited field studies to investigate other potential sources of BrC in urban environments. Hence, the formation and characteristics of BrC due to anthropogenic emissions remains poorly understood.

In this study, we aim to identify the major types of BrC and quantify their light absorption properties in Singapore, a well-developed city in a warm and humid tropical region. A unique combination of a seven-wavelength Aethalometer (AE33, Magee Scientific) and a high-resolution aerosol mass spectrometer (HR-AMS, Aerodyne Research) was deployed to determine the light absorption properties of ambient black carbon (BC) and OA. Positive matrix factorization of the HR-AMS measurement identified five types of OA. The mass absorption cross-section (MAC) and absorption Angstrom exponent (AAE) of each type of OA were determined, assuming BC and OA are the major contributors to the total absorption at each wavelength.

This work provides evidence that two types of primary OA (POA) and the less-oxidised secondary OA (SOA) produced through local photochemistry were associated with fuel combustion-related sources and/or industrial emissions. These primary and secondary anthropogenic OA were strongly absorbing at shorter wavelengths (i.e., MAC at 370 nm = 1.1-1.87 m²/g), which are comparable to that of biomass burning OA reported in previous studies. The fresh SOA showed the strongest wavelength dependence (AAE ~ 6) among the five OA factors, and accounted for ~46% of the observed OA absorbance at 370 nm. In contrast, the absorption of more-oxidised SOA, that represents aged or background SOA, was negligible. The large difference of MAC values between the less- and more-oxidised SOA could be due to different SOA formation conditions (e.g. types of precursors and pollution levels) and degree of aerosol aging (e.g., photobleaching). Overall, our observations indicate that human activities can significantly affect both primary and secondary BrC formation in urban environments, and highlight the importance

of quantifying optical properties of urban OA for improving our understanding of aerosol-climate interactions.

A study of the morphology and effective density of externally mixed black carbon aerosols in ambient air using a size-resolved single-particle soot photometer (SP2)

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Abstract:

The morphology and effective density of externally mixed black carbon (extBC) aerosols, important factors affecting the radiative forcing of black carbon, were studied by using a tandem technique coupling a differential mobility analyzer (DMA) with a single-particle soot photometer (SP2). The study extended the mass-mobility relationship to large extBC particles with a mobility diameter (d_{mob}) larger than 350 nm, a size range was seldom included in previous tandem measurements of BC aggregates in the atmosphere. The experiment was conducted at an urban site in Beijing during a 19-day winter period from 23 January to 10 February 2018. Ambient dry particles were selected by the DMA, and the size-resolved extBC particles were distinguished from particles with a thick coating (internally mixed) according to the time delay between the incandescence signal peak and the scattering peak detected by the SP2. The masses of the extBC particles were then quantified. The time differences between the DMA size selection and the SP2 measurement were processed previously. The normalized number size distributions were investigated at the prescribed d_{mob} sizes in the range of 140–750 nm to provide the typical mass of extBC at each d_{mob} . On this basis, the mass-mobility relationship of the ambient extBC was established, inferring a mass-mobility scaling exponent (D_{fm}) (an important quantity for characterizing the morphology of fractal-like BC aggregates) with a value of 2.34 ± 0.03 in the mobility range investigated in this study. This value is comparable with those of diesel exhaust particles, implying a predominant contribution of vehicle emissions to the ambient extBC in urban Beijing. Compared to the clean period, a higher D_{fm} value was observed in the polluted episode, indicating a more compact BC aggregate structure than that in the clean period. The effective densities (ρ_{eff}) of the extBC in the same d_{mob} range were also derived, with values gradually decreasing from 0.46 g cm^{-3} at 140 nm mobility to

0.14 g cm⁻³ at 750 nm mobility. The pe_{eff} values were slightly lower than those measured using the DMA-aerosol particle mass analyzer (APM) system. The difference in pe_{eff} values was likely due to the lower BC masses determined by the SP2 compared to those measured by the APM at the same mobility, since the SP2 measured the refractory BC (rBC) mass instead of the total mass of the BC aggregate, which consists of both rBC and a possible fraction of nonrefractory components measured by the APM. Higher pe_{eff} values were observed in the 280–350 nm dmob range, and were much closer to the values for soot aggregates reported in the literature. The higher pe_{eff} values might be related to the more compact structure of BC aggregates in this range, resulting from the reconstruction effect by volatile and/or semivolatile components in the atmosphere. The reconstruction effect might also result in a hiatus in the increased dynamic shape factor in the range of 200–350 nm which generally increased from 2.16 to 2.93 in the 140–750 nm dmob range.

Direct Observations of Fine Primary Particles From Residential Coal Burning: Insights Into Their Morphology, Composition, and Hygroscopicity

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Abstract:

Emissions of residential coal burning are an important contributor to air pollution in developing countries, but few studies have yet comprehensively characterized the physicochemical properties of individual primary particles from residential coal burning. Fine primary particles emitted from eight types of coal with low, medium, and high maturity were collected in the flaming and burn-out stages in a typical residential stove. Based on morphology and composition of individual particles, they were divided into six types: organic matter (OM), OM-S, soot-OM, S-rich, metal, and mineral particles. Low-maturity coals (e.g., lignite) dominantly emitted soot-OM particles in the flaming stage; the medium-maturity coals (e.g., medium-maturity bituminous coals) emitted abundant OM particles; and high-maturity coals (e.g., anthracite) emitted abundant OM-S particles. We found that carbonaceous particles from coal burning significantly decreased with an increase of coal maturity; and that soot particles were mainly formed in the flaming stage of low-maturity coals under higher burning temperatures. We concluded that coal maturity and burning temperature both determine particulate properties in coal emissions. In addition, OM and soot particles from residential coal burning displayed extremely weak hygroscopicity, while inorganic salts within individual particles determined particle hygroscopic growth. Understanding the characteristics of particulate matter emitted from residential coal burning is helpful to trace sources of ambient particles and clarify their possible ageing mechanism in air influenced by coal burning emissions. Our results suggest that air quality improvements can benefit substantially from the replacement of low- and medium-maturity coals with high-maturity coals, natural gas or electricity in rural areas.

Impacts of Emission Source and Aging Process on Black Carbon Size Distribution and Mixing State: Implications for Climate Effects of Black Carbon

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Abstract:

Black carbon (BC), as a strong light absorber in the atmosphere, plays an important but uncertain role in the climate system. BC's effects on the climate strongly depend on the size distribution and mixing state, which were influenced by emissions source and subsequent aging process. In order to characterize the key properties of BC, three field campaigns were carried out between 2015-2016 in various atmospheric environments including urban, rural and remote mountaintop sites. By using a coupling Scanning Mobility Particle Sizer and Single Particle Soot Photometer system, BC was generally found to follow a bimodal distribution with the mean diameters of approximately 110 nm and 160 nm, possibly attributed to urban emission and biomass burning emission, respectively. The contribution of the urban emission to the total BC number concentrations showed a growing trend during pollution episodes, indicating that the urban emission exerted a more significant effect on the regional air pollution. Additionally, it was found that long-range transport has minor influence on BC core diameter. The mixing state of BC showed considerable variation in various atmospheric environments: the coatings on the BC core were thicker in more remote site and in higher pollution levels, implying that the aging process had a profound impact on BC mixing state. The increase of coatings was associated with increasing proportion

of secondary inorganic aerosols and oxygenated organic aerosols, implicating that the secondary formation was an essential process of soot aging. The coatings on BC induced an absorption enhancement of BC, depending on both the coating mass and its chemical compositions, which was further evaluated by an atmospheric radiative transfer model to calculate the direct radiative forcing of BC. This study revealed the microphysical properties of BC in a wider range of atmospheric environments and provided broad evidence for the impact of emission source and aging process on changing the properties of BC, which ultimately affected its role in both regional air pollution and global climate change.

Mixing states of the black carbon in the East China and its associated source

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Abstract:

Black carbon (BC) is the dominant light-absorbing aerosol component in the atmosphere and its effects on the Earth's radiative balance remain large uncertainty in climate models. In the atmosphere BC particles have a complex structure and its mixing state and sources have crucial impact on aerosols' optical properties.

To investigate the mixing state of the black carbon aerosol and the contributions of biomass burning and traffic emission, an intensive field campaign was conducted at a downwind rural site, Taizhou, China in the summer of 2018 (May 18th -June 16th), which represents the regional atmospheric characteristics of Yangtze River Delta.

We combined the techniques of Centrifugal Particle Mass Analyser (CPMA) and Single Particle Soot Photometer (SP2) to quantify the mass of non-BC (M_{non-BC}) material, i.e. coating mass. This technique can directly and accurately measure the coating mass without any assumptions for the density or refractive index. A CPMA classified pre-charged particles by their mass-to-charge ratio, and a SP2 detected the mass of refractive black carbon (M_{rBC}) in each individual particle through a laser-induced incandescence (LII) method. The particle distributions were constructed using the inversion over a range of 2.91-50 fg of total particle mass. In this study, we quantify the mixing state of individual BC particles using the mass ratio, i.e. $MR=(M_p - M_{rBC})/M_{rBC}$. Our results showed that the coating thickness is highly dependent on the photochemical age of the air mass. The analysis of low, medium and extremely high BC concentrations indicated that there are two different sources of BC with different mixing states, which are local fresh biomass burning (large BC core mode with $M_{rBC}>1.5\text{fg}$) and traffic emission (small

BC core mode with $M_{rBC} < 1fg$). Such analysis will provide particularly significant information for the further investigation of mixing states and sources of BC by a morphology-independent measurement under complex air pollution.

HIGH TIME RESOLUTION MEASUREMENT AND SOURCE APPORTIONMENT OF TC, BC and OC, EC

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Abstract:

Measurements of carbonaceous aerosols are of vital importance for local, regional and global air quality monitoring, regional and global climate change investigations. The carbonaceous fractions are frequently separated into organic carbon (OC) and elemental carbon (EC) based on their volatility using thermal-optical methods. While the results for OC and especially EC concentrations vary significantly for different thermal evolution protocols, the total carbon (TC) concentration is very consistent between methods (Karanasiou et al., 2015). Therefore, we show an equivalent method and a new and innovative instrument, capable of highly time resolved measurement of total carbon (TC), which, combined with black carbon (BC) measurements (Drinovec et al., 2014; Hansen et al., 1982), provides an equivalent of OC and EC. We call this approach TC-BC.

“TC-BC” online method combines an optical method for measuring BC by the Aethalometer AE33, and a thermal method for TC determination by the Total Carbon Analyzer TCA08 is used for source apportionment of carbonaceous aerosols with high time resolution at several measuring sites around the world. TC-BC method determines equivalent organic carbon fraction of carbonaceous aerosols as

$$eOC = TC - b \cdot BC,$$

where $b \cdot BC$ is equivalent to elemental carbon (EC). The determined proportionality parameter b is region/site specific and depends to a large extent on a thermal protocol used to determine the EC fraction with the conventional OC/EC method.

TCA08 measures concentration of TC by a rapid combustion of carbonaceous matter (CM) collected on a quartz filter. Pulse of CO₂ which is created during combustion phase of the analysis is detected as a large transient increase above the CO₂ level in the ambient air used as the carrier gas. Simplicity of the analysis allow us to have high time resolution measurement and easier field deployment of the instrument as no high purity gases are needed.

TC-BC method was validated by comparing averaged high time resolved data to the conventional OC/EC analysis on 24h filters using different thermal protocols (EUSAAR2, IMPROVE, NIOSH) in the winter campaigns in Europe, Asia and N. America: Ljubljana (Slovenia), urban background site; Loški Potok (Slovenia), rural; Ispra/Milano (Italy), urban background, Paris (France), urban background; London (United Kingdom), urban background; Zurich (Switzerland), urban background; Magadino (Switzerland), rural; Beijing (China), urban; New Delhi (India), urban; Los Angeles (United States of America), urban; Additionally, at some sites parallel measurements with aerosol mass spectrometry (AMS or ACSM) allowed us to obtain hourly comparison of OM (AMS) to OC (TC-BC) and determine the OM/OC ratio.

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Dominant contribution of oxygenated organic aerosol to haze particles from real-time observation in Singapore during an Indonesian wildfire event in 2015

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Abstract:

Recurring transboundary haze from Indonesian wildfires in previous decades significantly elevated particulate matter (PM) concentrations in Southeast Asia. During that event on 10 to 31 October 2015, we conducted a real-time observation of non-refractory submicron PM (NR-PM₁) in Singapore using an Aerodyne aerosol mass spectrometer. Simultaneously, we characterized carbonaceous components and organic aerosol (OA) tracers from fine PM (PM_{2.5}) samples to support source apportionment of the online measurements. The real-time analysis demonstrated that OA accounted for approximately 80 % of NR-PM₁ mass during the wildfire haze period. Source apportionment analysis applied to the OA mass spectra using the multilinear-engine (ME-2) approach resulted in four factors: hydrocarbon-like OA (HOA), biomass burning OA (BBOA), peat burning OA (PBOA), and oxygenated OA (OOA). The OOA can be considered as a surrogate of both secondary organic aerosol (SOA) and oxidized primary organic aerosol (OPOA), while the other factors are considered as surrogates of primary organic aerosol (POA). The OOA accounted for approximately 20-50 % of the total OA mass in NR-PM₁, while POA subtypes from wildfires (BBOA and PBOA) contributed to approximately 30 % of the total OA mass. Our findings highlight the importance of atmospheric chemical processes, which likely include POA oxidation and SOA formation from oxidation of gaseous precursors, to the OOA concentration. As this research could not separately quantify the POA oxidation and SOA formation processes, further studies should attempt to investigate the contribution of gaseous precursor oxidation and POA aging to the OOA formation in wildfire plumes.

Chemical and optical properties of BC-containing particles in urban and remote sites of China

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Abstract:

Refractory black carbon (rBC) aerosol is a very important climate forcer, and its impacts are greatly influenced by the species associated with rBC cores. However, relevant knowledge is lacking due to scarcity of surface observations. Here we present highly time-resolved measurement results of rBC and its coating species at a high altitude remote site in central TP (4730 m a.s.l), and in urban Beijing, China, respectively, by using an Aerodyne soot particle aerosol mass spectrometer (SP-AMS), which exclusively measured rBC-containing particles only. Such two cases represent the very clean and highly polluted environments in China. We found that the rBC over TP was overall thickly coated with an average mass ratio of coating to rBC (RBC) of ~ 7.7 , and the coating species were predominantly secondary in nature, mainly produced by photochemical reactions. Interestingly, we found that the thickly coated rBC was less oxygenated than the thinly coated rBC, mainly due to the influence of a transported biomass burning organic aerosol (BBOA). This BBOA was relatively fresh but able to form very thick coating on rBC. On the other hand, rBC-containing particles in urban Beijing were overall associated with thinner coating, and the organic coating had diverse sources including both primary and secondary origins; On average, more polluted rBC-particles appeared to have thicker coating and more secondary species. We also discussed the light absorption enhancement due to the coating under these two cases.

Influences of primary emission and secondary coating formation on the mixing state of black carbon-containing particles

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Abstract:

Black carbon (BC) emitted from incomplete combustion can result in significant impacts on air quality and climate. Understanding the mixing state of ambient BC and the chemical characteristics of its associated coatings is particularly important to evaluate BC fate and environmental impacts. In this study, we investigate formation of coating on BC particles and aerosol mixing state near traffic emissions under hot and dry conditions in Fontana, California using an Aerodyne soot-particle aerosol mass spectrometer (SP-AMS). The SP-AMS was operated in a configuration that can exclusively detect refractory BC (rBC) particles and their non-refractory coating materials, including organic, nitrate, sulfate, ammonium and chloride.

Substantial formation of secondary organic aerosol (SOA) coatings on rBC particles was observed due to active photochemistry in the afternoon, whereas primary organic aerosol (POA) components were strongly associated with rBC from fresh vehicular emissions in the morning rush hours. Nitrate peaks were observed in the late morning due to formation of nitric acid via OH radical oxidation of NO₂ in traffic emissions. Using the $-\log(\text{NO}_x / \text{NO}_y)$ ratio as a proxy for photochemical age of air masses, most of the observed SOA coatings were freshly formed, providing an opportunity to examine SOA coating formation on rBCs near vehicular emissions. Comparison of our results to a co-located standard high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) measurement suggests that approximately 7–20 wt % of secondary organic and inorganic species were estimated to be internally mixed with rBC on average, implying that rBC is unlikely the major condensation sink of secondary species.

Event Trigger mode of SP-AMS was used to measure chemical composition of individual rBC-containing particle. Preliminary results of cluster analysis of single-particle measurements indicate the presence of various types of primary and secondary coatings based on their mass spectral characteristics. The mixing state index was calculated for quantifying the degree of mixing of rBC and coating materials (i.e., mixing state index = 0 and 1 means that all particles are fully externally and internally mixed, respectively). The mixing state index varied between 0.2 and 0.6 with the average of 0.38 (± 0.06) in this study, and was not sensitive to the photochemical age of air masses. Nevertheless, the average particle species diversity and the bulk population species diversity, which represent the average effective number of species in each particle and the effective number of species in the population, respectively, slightly increased with primary traffic emissions and/or nitrate formation but gradually decreased with SOA formation during the afternoon. These observations indicate that substantial SOA formation observed in the afternoon led to more homogeneous particle compositions.

Formation and evolution of aqSOA from aqueous-phase reactions of phenolic carbonyls: comparison between ammonium sulfate and ammonium nitrate solutions

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Abstract:

We investigate the effects of sulfate and nitrate on the formation and evolution of secondary organic aerosol formed in the aqueous phase (aqSOA) from photooxidation of two phenolic carbonyls emitted from wood burning. AqSOA was formed efficiently from the photooxidation of both syringaldehyde (C₉H₁₀O₄) and acetosyringone (C₁₀H₁₂O₄) in ammonium sulfate and ammonium nitrate solutions, with mass yields ranging from 30% to 120%. Positive matrix factorization on the organic mass spectra acquired by an Aerosol Mass Spectrometer revealed a combination of functionalization, oligomerization and fragmentation processes in the chemical evolution of aqSOA. Functionalization and oligomerization dominated in the first 4 hours of reaction, with phenolic oligomers and their derivatives significantly contributing to aqSOA formation; and oxidation of the first-generation products led to an abundance of oxygenated ring-opening products. Degradation rates of syringaldehyde and acetosyringone in nitrate solutions were 1.5 and 3.5 times faster than rates in sulfate solutions, and aqSOA yields in nitrate experiments are twice as high as in sulfate experiments. Nitrate likely promoted the reactions because it is a photolytic source of OH radicals, while sulfate is not, highlighting the importance of aerosol-phase nitrate in the formation of aqSOA by facilitating the photooxidation of organic precursors.

Seasonal light absorption properties of water-soluble brown carbon in atmospheric fine particles in Nanjing, China

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Abstract:

Recently atmospheric brown carbon (BrC) is recognized as an important contributor to light absorption and positive climate forcing. This work investigated the light absorption properties and sources of water-soluble BrC in atmospheric fine particles collected from 4 May 2015 to 4 May 2016 in Nanjing. We also conducted chemical analyses of OC, EC, WSOC, K⁺, and SP-AMS analyses on the water-soluble organics. We found that winter samples had the strongest light absorption among four seasons. The light absorption at 365 nm (Abs₃₆₅) for all seasons linked closely with secondary organic carbon (SOC), indicating a dominant contribution from secondary sources to BrC. However primary biomass burning might also contribute to BrC as revealed by the good correlations of Abs₃₆₅ versus levoglucosan fragments and/or K⁺, and such influence was more evident during summer. Furthermore, an Aerodyne soot-particle aerosol mass spectrometer (SP-AMS) was employed to determine the elemental ratios of BrC. We found that except in winter, the Abs₃₆₅ in general positively correlated with the average oxidation states (OSc) of BrC, suggesting more BrC were produced at higher OSc. The mass absorption efficiency at 365 nm (MAE₃₆₅) showed no clear dependences on OSc during spring, summer and fall, but decreased against OSc during winter, indicating chemical aging may lead to photo-bleaching of WSOM in winter. Moreover, positive responses of Abs₃₆₅ to N/C ratios were found during all seasons, indicating nitrogen-containing organics can be important BrC chromophores. PSCF analyses further showed the different source regions to BrC during different seasons, and in particular, pointed out that biomass burning in North China Plain or sometimes southern China could have more impacts on BrC during summer and winter (especially February in this work). To further understand the relation and relative source contribution of different OA factors to BrC absorption, positive matrix factorization (PMF) analysis was performed on the high-resolution mass spectra, where the WSOA was further divided into POA factors and SOA factors based on their characteristics. Then the absorption by BrC was apportioned to the OA factors by a multiple linear regression model. Light absorption properties of water-insoluble species, quantification of the contributions from primary and secondary sources to BrC, and the molecular characterization of possible BrC chromophores, etc. are also discussed.

Atmospheric Aerosol Chemistry: Climate and Air Quality

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Abstract:

Despite much effort in the past decades, uncertainties in both climate impacts and health effects of atmospheric aerosols remain large. During the last ten years, aerosol mass spectrometry (AMS) has shown that sub-micron aerosol chemical composition is roughly 50:50 inorganic and organic worldwide, with secondary highly oxidized organics dominating the latter. Parallel application of chemical ionization mass spectrometry (CIMS) has provided the first observation of molecular cluster ions involved in atmospheric nucleation, including detection of highly oxidized multifunctional (HOM) organics in the gas phase. These results will be discussed in the context of their impact on atmospheric aerosols, air quality and climate.

Development of a double-shrouded probe for particle sampling in high-velocity flows

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Abstract:

At present, the problem of air pollution due to fine dust is emerging all over the world and Korea is one of the most affected countries. In order to reduce the damage caused by such environmental problem, fine dust forecasting through accurate measurement of fine dust concentration is essential. Nowadays the aerosol concentration is mainly measured at stationary observation stations on the ground. However, methods of conducting fine-dust-measurement over a wide area using UAVs (unmanned aerial vehicle) are actively researched to get a lot more aerosol concentration measurement data, enabling a more accurate forecast of fine dust concentration. For the measurement through the UAVs, it is essential to have a specially designed sampler to obtain the accurate aerosol concentration even under the high-speed and low-pressure conditions in the troposphere. For this purpose, we developed a double-shrouded probe in which the two layers of cylindrical shroud structures surround the sampling tube. The operating speed and pressure range of the double-shrouded probe were set to 0-300 km/h and 0.3-1 atm, respectively, considering the normal speed of the air vehicles and the pressure conditions in the troposphere. To verify the aspiration ratio of the double-shrouded probe, simulations using a commercial software and experiments with a specially designed wind tunnel were conducted. As a result, it was confirmed that the accurate aspiration ratio could be acquired for PM_{2.5} aerosol particles even under the high-speed and low-pressure conditions in the troposphere. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning, Grant number: 2017R1A2B2006927. ysjnuri@hayang.ac.kr.

A Cost-effective, Surface Area Sensor for PM Surface Area Concentration Monitoring

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Abstract:

The characterization/monitoring of geometrical surface area concentration of particles, one of key integral parameters of particle size distribution, are required in particle studies related to air quality and pollution, public health, worker protection, industrial processes and many others (due to its relevance to chemical reaction). The electrical technique, i.e., electrically charging particles and detecting the charges carried by particles, is widely applied in the majority of so called “Electrical Aerosol Detectors” (EADs) for measuring total surface area concentration of particles (because of its simple design). Three key components are typically included in these EADs, i.e., particle charge conditioner, ion trap and aerosol Faraday cage with a sensitive electrometer. However, all the existing EADs are semi-empirical sensors. It is because these sensors empirically correlated the measured particle current with the total surface area concentration of particles, derived from the measured size distribution of particles (via particle sizers), using test particles. As a result, the included correlation only applies to the cases with the size distribution similar to that of test particles. In addition, the inclusion of an aerosol in the sensors increases the sensor and operation cost and (i.e., requiring to replace the filter in the cage). The objective of this work is to have a cost effective sensor capable of measuring the total surface area concentration of particles (assuming in the spherical shape) with a universal correlation.

In this study, a new electrical sensor, consisting of a unipolar particle charger, a disk precipitator and an electrometer, was designed and its performance was experimentally evaluated for the measurement of particle surface area concentration. Instead of measuring the current carried by escaped particles in existed sensors, the new sensor measured the current carried by particles deposited on the precipitator. The overall sensor construction was thus reduced without the Faraday cage (compared with that of existed ones). By tuning the operational parameters of studied sensor, the requirement that the signal of studied sensor is proportional to the square of particle size was achieved. The obtained correlation between the sensor signal and particle surface area concentration is consequently universal for particles in all the size distributions (assuming in spherical shape). In this presentation, the operational principle and design logic of studied sensor will be given. The sensor testing result using sample solid/liquid particles with different size distributions (i.e., different mean sizes and geometrical standard deviations) will be discussed.

Measurement of particle size distribution of high-concentration aerosols with centrifugal filter

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Abstract:

In the production of functional particles by gas phase reactions, measurement of the concentration and size distribution of particles in manufacturing processes is important in order to control the properties of particles. Most of the measuring instruments are developed for the atmospheric particles of low concentrations so that a large dilution is required in measuring high concentration aerosol particles with the conventional instruments, which often causes large particle loss and particle size change as well as the composition change due to the evaporation of volatile components. Therefore, the development of instrument which measures the size distribution of high-concentration aerosol in real time without dilution is mandatory.

In the present work, the centrifugal filter proposed by the authors (Nakajima et al. 2015) was applied to measure the size distribution of high-concentration aerosol particles. Since the collection efficiency of centrifugal filter is varied by changing the rotation speed of filter (Nakajima et al. 2015) to attain various cut-off sizes, it may be combined with a particle detector which does not have size-discrimination capability to form a new type of measurement system. By scanning the rotation speed of centrifugal filter followed by the detection of total aerosol concentration, and applying an appropriate inversion scheme from the particle penetration to the size distribution, we may construct a real time aerosol measurement system based on the aerodynamic size as SMPS measures the size distribution based on mobility diameter by scanning the voltage. However, because the classification performance of the centrifugal filter is not so sharp, we used Twomey's inversion algorithm to retrieve the particle size distribution from the particle penetration at various rotation speeds. We applied this technique to the measurement of size distribution of Kanto Loam test dust (JIS-11) dispersed by a fluidized-bed aerosol generator (Model 3211, Kanomax Inc.) The particles were electrically neutralized and mixed with clean air to make different concentrations of aerosol by changing the dilution ratio. The particle penetration was continuously measured with a photometer (Dust track, Model 8530, TSI) by changing the rotation speed of centrifugal filter. The retrieved particle size distribution from the particle penetration was compared with those measured by an optical particle counter (OPS, Model 3330, TSI) after dilution. As a

result, we found that the dilution of aerosol introduces a large loss of coarse particles whereas the proposed centrifugal filter can measure the size distribution of high concentration aerosols without the loss of coarse particles.

Development of a high performance single particle mass spectrometer

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Abstract:

Single particle mass spectrometry (SPAMS), which can simultaneously determine the aerodynamic size and chemical composition of individual aerosol particles in real time, has been extensively used in atmospheric studies. In recent years, SPAMS has played an important role source apportionment of PM_{2.5} in China, providing helpful information for the better control of haze pollution. However, the application of SPAMS is still limited, for example, much higher sensitivity is required for much less polluted areas, like Polar Regions and, higher mass resolution is needed for complicated samples. In this study, the development of a high performance single particle spectrometer was described. First of all, the sampling flow rate is improved from 100 mL/min to 500 mL/min by adding a particle concentrator to the front of the aerodynamic lens. Meanwhile, the vacuum load of the system is not increased based on the virtual impactor principle. Secondly, a significant progress has been made on mass resolution, increasing from 500 (FWHM) to more than 2000 (FWHM). This is attributed to a special delayed pulse developed in our study, which is now implemented to the bipolar time of flight mass spectrometer. Thirdly, the time resolution of measurement becomes better compared with the last version. A diode solid laser at 100Hz repetition rate and with improved beam performance is adopted instead of the original 20 Hz laser. For the new version of SPAMS better hit rate is achieved due to the absence of electric field in the ion source region. Moreover, the SPAMS data acquisition system has also been improved by applying a high dynamic system with two acquisition channels. These two channels can combine both strong and small signal and thus successfully overcomes the disadvantages of previous SPAMS in the detection of small signals. The old version of acquisition card was readily over-ranged by strong signals from ion species like Na⁺, K⁺, which SPAMS is very sensitive to. To summarize, the SPAMS developed in this study will significantly extend the application of the instrument in atmospheric sciences.

An overview on evaluation of the new capture vaporizer for Aerosol Mass Spectrometers (AMS)

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Abstract:

The Aerosol Mass Spectrometer (AMS) and Aerosol Chemical Speciation Monitor (ACSM) are widely used for quantifying submicron aerosol mass concentration and composition. Using the standard vaporizer (SV) installed in almost all currently-operating instruments, a collection efficiency (CE) correction, varying with aerosol phase and chemical composition, is needed to account for particle bounce losses, which dominate the uncertainty on quantification of concentrations. To address this limitation, a new capture vaporizer (CV) was recently built and tested in various laboratory and field measurements. Here, we present an overview of results on CV quantification and spectrum characterization for laboratory-generated compounds and ambient aerosols, with comparisons results from co-sampled SV-AMS and other independent measurement. We found CV-AMS has an improved CE for less volatile compounds (e.g., pure $(\text{NH}_4)_2\text{SO}_4$ in the lab) and achieves $\text{CE} \sim 1$ for ambient aerosols. However, the CV chemical detection properties show some differences from the SV due to the increased residence time of particles and vaporized molecules inside the CV, and different vaporizer materials. The effects of oxidation and heating of aerosols on quantification using both vaporizers is also examined. Artifact CO^+ ions (and to a lesser extent, H_2O^+), when sampling long chain reduced OA (e.g. squalene) in

the CV, are observed, probably caused by chemical reactions between sampled OA and molybdenum oxides on the vaporizer surfaces (with the carbon derived from the incident OA). No evidence for such CO₊ enhancement is observed for highly oxidized species and ambient OA. The elemental composition and source apportionment (PMF) with the CV can be accurately determined after proper calibration. The size distribution broadening is significant for monodisperse particles, but its impact is limited in field studies since ambient distributions are typically quite broad. Consistent size distributions of ambient aerosols were measured with the SV and CV after calibration. Finally, we summarize all the relevant pros and cons when using the CV versus SV.

A New Multiple-Ionization Single Particle Aerosol Mass Spectrometer: Rapid On-line Analysis of Toxic Polycyclic Aromatic Hydrocarbons (PAH), Metals (Pb, Zn etc.) as well as Anionic Source Marker Compounds on Individual Airborne Aerosol Particles

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Abstract:

Single-particle aerosol MS (ATOFMS) based on laser desorption/ionization (LDI) is a versatile method for characterization of airborne particles. Currently available ATOFMS-technologies detect mainly inorganic species. Recently also ATOFMS-approaches for an on-line single particle detection of polycyclic aromatic hydrocarbons (PAH) were developed (Bente et al., *Anal.Chem.* 2008, 8991ff). The particles are desorbed by an IR-laser (LD) and subsequently the PAH are ionized by resonance-enhanced multiphoton ionization (REMPI with UV-laser pulse) for MS detection. A drawback here is, however, that the LDI-information on the inorganic particle-composition is lost. Here we presents a newly developed and patented multi-step laser-ionization ATOFMS-concept for detection of organic species (LD-REMPI) and element signatures (LDI) from the same individual aerosol particle. The approach is based on the sequential application of laser pulses in a dual-TOF mass analyzer for laser desorption (LD) and the REMPI- and LDI-laser ionization processes. The particle in the ion source is desorbed by an IR-laser pulse and the PAH

subsequently are ionized by a UV-laser pulse (REMPI) from a 248 nm KrF-excimer laser pulse. The 248 nm pulse is reflected back by a parabolic mirror and thereby is focused on the particle core for LDI. By this procedure in addition to the particle size, the REMPI-spectrum of the absorbed PAH-molecules as well as the LDI-spectrum, showing positive ions (such as K⁺, Fe⁺, Al⁺, V⁺ or Pb⁺) as well as negative ions (such as carbon clusters, SO₄⁻ or NO₃⁻) from the very same individual particles can be detected. First measurements of wood combustion and diesel-emission particles as well as ambient particles are shown. On-line multi-step ATOFMS represents a new promising technology for rapid on-line analysis of micro- and nano-particles for atmospheric source apportionment, internal and external mixing state-analysis of inorganics and organics or industrial process analysis.

Improving the accuracy and precision of sub-3 nm nanoparticle measurements

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Abstract:

Any measurement includes three types of uncertainties: randomness, systematic bias and human caused errors. With respect to sub-3 nm nanoparticle measurements, we discuss how inherently random particle distribution in a given volume affects the counting statistics in a differential mobility particle sizer (DMPS) systems. We operate two CPCs with different counting statistics in a single DMPS system, and discuss the relation between the random error and measurement error, and for the first time infer the DMPS measurement error directly from the counting statistics. Next, we present a new Halfmini DMA based DMPS system and show its performance compared to a standard monitoring ultrafine DMPS. Then, we discuss the recently introduced Π parameter, which is proposed as the figure of merit for a sub-3 nm DMPS systems. In addition to the conventional particle penetration to characterize a sub-3 nm DMPS, Π includes all the instrumental factors affecting the counting statistics. Using the Π parameter, we show how the systematic and random error can be decoupled, and sub-3 nm DMPS system operation optimized in terms of the DMA resolution. Last, if time permits, we discuss briefly how the composition of the sampled particles causes systematic bias to the measurements, which easily leads to significant error in the measured particle concentration.

Effectiveness of automotive cabin air filters to protect passengers against air pollution during a life cycle.

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Abstract:

Recently, increasing attention has been paid to indoor air quality, due to the airborne pollutants can be inhaled or attach to human bodies, they are suspected to be etiological agents for both human infectious and respiratory diseases. Especially, in an urban environment, although commuters typically spend only 6% of the day or 1.5h in an automobile, automobile cabin indoor air quality is most significant due to the health risks of exposure to the high concentration of harmful air pollutants inside the automobile cabin indoor environment.

Automobile generates a complex mixture of gases and particles formed by incomplete combustion, volatilization of unused fuel, and release of engine lubricating oil. Thus, the concentration of PM on the roadways can reach very high levels, typically on the 105 particle/cm³. These high concentrations of particulate matter penetrate the automotive cabin environment through automotive heating, ventilation, and air conditioning (HVAC) system.

In addition, the emission of volatile organic compounds (VOCs) from automobile cabin materials is one of the main causes of poor automotive cabin air quality. Recently, the "Sick Car syndrome" has been highlighted as a result of the identification of toxic VOCs such as benzene (B), toluene (T), ethylbenzene (E) and xylenes (X), which emitted from the dashboard, door panels, seat coverings, and flooring materials. Therefore, during daily commutes and drivers are exposed to high concentration of airborne pollutants emitted from surrounding automobile or interior materials.

In general, a possible solution for individual occupants would be to use the cabin air filter to improve automotive cabin air quality. Thus, to reduce automotive cabin exposure to airborne pollutants, modern automobiles are commonly equipped with cabin air filters. PM concentration in an automotive cabin to mimic the outdoor concentration at a slightly lower level due to adherence to transfer ducts and cabin air filters. However, the performance of the automobile cabin air filter against airborne pollutants is not confirmed. Recently, few studies have focused on the filtration efficiency of automobile cabin air filter. However, previous studies have been only performed to estimate the filtration efficiency of the particulate matter.

This study aims to evaluate the filtration efficiency of cabin air filters in reducing exposure to cabin air pollution. We evaluated the filtration efficiency of commercial cabin air filters for particulate matter ranging from 0.3 to 10 μm and 2 type gases (toluene, n-butane). The filtration efficiency was also evaluated under a range of filter face velocities and estimated usage levels. The findings can elucidate sources of effects of air filters on automotive cabin air pollution and are expected to provide useful guidelines for automotive cabin IAQ.

This research was supported by the Environmental Industry & Technology Institute (2017001960003), and KITECH Institutional Program (JA-19-0038), Republic of Korea.

The Study of Filtration Characteristics of Ultra-Fine Fibers Filter Produced by Electrospinning

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Abstract:

Filtration is a technique for collecting samples of aerosol particles. Conventional fibrous materials have larger fibers diameter, resulting in higher filtration resistance due to the direct impact of air molecules on the fiber surface. The air molecules could more easily travel through the filter as the fiber diameter gradually approached the mean free path of air molecules due to the developing slip flow. The spinning solution was prepared using nylon-6 (PA-6), sodium chloride (NaCl) and formic acid (FA). Using electrospinning system produced fibers diameter. The study set up a filtration system to evaluate the performance of fibers filter. This study evaluated the performance of fiber filters by aerosol penetration and filtration quality. Using the ratio of downstream and upstream number concentration to calculated penetration of fiber filters. Then, used the aerosol penetration and pressure drop to calculated filter quality. Select a support layer with lower pressure drop and higher filter quality as the substrate of nanofibers. Ultra-fine fiber filter was compared with two commercial filters of filtration performance. Lower polymer concentrations reduce the polymer chains entanglement in solution. The conductivity of the spinning solution is increased by the addition of salts to increase the tensile force of the fibers, producing ultra-fine fiber. Average diameter of ultra-fine fibers is 63 nm. Impedance of mesh is lower than support layers of commercially available filter and has the highest filtration quality. However, the interwoven structure of mesh causes the nanofiber to form a film as the collection time increases, resulting in an increase in the impedance of the filter and a decrease in the filtration quality. Therefore, the support material of the commercially available filter having the lowest impedance was selected as the substrate of the nanofiber. Collection time of ultra-fine fiber filters is 10 ~ 180 sec. Most penetrating particle size

(MPPS) of ultra-fine fiber is about 150 ~ 250 nm. When fibers collection time is increased, aerosol penetration is decreased from 85 to 73% and pressure drop of fiber filters is raised from 0.25 to 0.46 mm-H₂O. From 0.65 rise to 1.0 and then increased to 0.7. Collection time 60 sec has the highest quality factor. Average diameter of two commercial filters is 4.2 μm. MPPS is about 40 ~ 50 nm. Aerosol penetration is 2.3 ~ 2.5%. Pressure drop is 6.37 ~ 8.6 mm-H₂O. Quality factor of 0.43 ~ 0.5. Mesh is used as a support material for nanofibers, fiber spray is easy to form a film, so that the impedance is rapidly increased, and it is not easy to use a commercially available filter as a support material for the

nanofiber. The pressure drop of nanofiber filters is increasing with rising the collection time in the process of electrospinning caused by the surface area of fiber is increased. Nanofiber filter materials have low impedance and high filtration quality, but the filtration efficiency is still lower than commercially available filter. In the future, nanofibers can be prepared in a laminated manner to achieve high filtration efficiency, low impedance, and high filtration quality.

Factors Affecting Particle Depositions on Electret Filters Used in Residential HVAC Systems and Indoor Air Cleaners

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Abstract:

Filters made from electret materials with quasi-permanent electrical charges have been widely applied to control particulate matter (PM) pollution. However, studies using parametric analysis to examine the effects of the operating face velocity, charge density, and fiber diameter, porosity, and thickness on the energy efficiency of the filtration are lacking. A reliable parametric analysis requires an accurate filtration model. Without adding any empirical parameters, a modified model developed earlier by the authors was the first to accurately predict the efficiency of electret filters at different face velocities and with different filter charge densities for neutralized particles. To further verify the applicability of this model, we conducted filtration experiments in which singly charged, neutral, and neutralized monodisperse particles (diameter: 3–500 nm) were passed through two different electret filters, one with a charge density of 0.075 and the other with a charge density of 0.025 mC m⁻², as well as through discharged electret filters; the results of the modified model agreed well with the experimental data. The validated model was then used to conduct a parametric analysis to clarify the effects of the aforementioned parameters on filter performance, and it was found that the increase in efficiency due to the fibers' charge state varied largely with the face velocity and the charge density of the electret. Furthermore, when the pressure drop was held constant, using thicker filters with less solidity reduced particle penetration. The results in this work can be applied to the design and operation of future electret filters.

Numerical investigation of evolution of aerosol size distribution under combined effect of heterogeneous condensation and acoustic agglomeration

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Abstract:

The fine particles or PM_{2.5} whose aerodynamic diameters are not greater than 2.5 μm have been an important environmental concern. These particles are generated mainly from high temperature processes of coal-fired power plants, industrial plants and vehicles. Because of their tiny sizes, it is extremely difficult for the conventional particulate removal devices to remove PM_{2.5} from the flue gas. The fact that particulate removal devices like bag filters and electrostatic precipitators can achieve very high efficiencies for particles larger than 3 μm leads to the interests in developing fine particle preconditioning technologies in order to enlarge the particle sizes above 3 μm . The preconditioning technologies include acoustic agglomeration and heterogeneous condensation. However, literatures indicate that high energy consumption is required to achieve a desirable removal efficiency of PM_{2.5} by single effect of acoustic agglomeration or vapor condensation. In order to improve the performance of particle size enlargement at low energy consumption, the PM_{2.5} agglomeration technique under the combined effect of acoustic agglomeration and vapor condensation has been developed. The objective of this work is to model the aerosol dynamics under the combined effect of acoustic field and vapor condensation and to numerically investigate the evolution of particle size distribution under the combined effect in order to provide a fundamental understanding of the aerosol size enlargement process. The classical heterogeneous nucleation theory and the condensation droplet growth theory, as well as all of the important particle interactions in acoustic agglomeration, e.g., orthokinetic interaction, gravity sedimentation, Brownian diffusion, mutual radiation pressure were taken into account to model the aerosol dynamics. The model predicted particle size distributions after heterogeneous condensation and after acoustic agglomeration were compared with the experimental data to validate the model. Based on this, the particle size evolution under the combined effect were numerically investigated. The results show that a portion of particles are enlarged due to vapor condensation, which increases the differences in particle diameter and further enhances the particle interaction. The number removal efficiency of PM_{2.5} under the combined effect of acoustic field of 5 kHz and 135 dB and vapor condensation with saturation ratio of 1.12 increases by 7% compared with that under the effect of acoustic field of same frequency but a much higher intensity (5 kHz and 150 dB). Moreover, better

wettability of particles, higher initial saturation ratio and acoustic frequency facilitate particle agglomeration under the combined effect.

Enhancing the Efficiency of Flat-plate Electrostatic Precipitator by a Unipolar Ion Jet Generator

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Abstract:

Electrostatic precipitators (ESP) are mainly used for particulate matter collection, because of this technique gives high precipitation efficiency and a low pressure drop. Inside the ESP, aerosol are getting charged by discharge electrode and would be immediately collected by collection electrode. Once the voltage reaches breakdown voltage, it would cause arc or spark, and this may cause explosion if the waste gas contains volatile organic compounds (VOCs). Using diffusion charging can avoid pollution gas directly contact discharge electrode. Therefore, in this research, a unipolar ion generator with flat-plate electrostatic precipitator is designed for diffusion charge efficiency study. The subjects of particle in this research are setting 50 nm and 100 nm diameter sodium chloride particles. To achieve monodisperse particles is by using Kr85 neutralizer and LDMA to select 50 and 100 nm diameter particles. The unipolar ion generator uses a stainless steel needle to generate ions and then uses high velocity of clean airflow to jet ions to charge the particles. After mixing, these ions would flow out and charge the particles. Particle charge distribution and charge loss are measured by SMPS. In this case, SMPS's Kr85 would be replaced by empty stainless tube to observe the reality state in the particle charge distribution and charge loss. In the end, a small flat-plate electrostatic precipitator is made to collect particles. The result shows when the airflow raises, Unipolar Ion Generator would jet more ions from the electrode to charge particles, which indicates that more particles are charged. The result of 100 nm particle electric mobility is mainly in 0.48 cm²/stV-s, which charge is always in 6 units. And the result shows that charge loss fraction increases while airflow increases. The smaller particle is, the greater the charge loss is. Because smaller particles have greater chance to proceed intensive Brownian motion and precipitate in the duct wall. As a whole, this study discover that the unipolar ion generator combines with flat-plate type ESP particle penetration rate is far less than flat-plate type ESP. As conclusion, using unipolar ion generator can enhance the collection efficiency of Flat-plate type Electrostatic precipitator.

Effective extension of the electrostatic filter media lifetime with Thermoplastic Polyurethanes_x000B_

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Abstract:

There are five fundamental mechanisms can be used for particulate matter filtration, including interception, inertial impaction, diffusion, gravitational settling and electrostatic attraction. Among them, the electrostatic attraction is the most effective way to filter particles in the range of 100 to 400 nanometers. However, the filtration efficiency for most plastic filters can rapidly decrease in a high oil mist environment due to the loss of electrostatic charges. This effect is a serious concern in automobile applications.

To overcome this problem, we present our study on using thermoplastic polyurethanes (TPU) to create an oil resistant layer which can protect and prolong the performance of an electrostatic filter. TPU is a polymer that has superior elasticity and excellent oil resistance. To create a masking filter for protecting a standard melt-blown PP electrostatic filter, we used a standard dip coating method to coat TPU on a polypropylene (PP) non-woven fabric. Our experimental study shows that the filtration efficiency can be extended by using TPU coated non-woven filter to mask a standard PP electrostatic filter. After study the penetration profile of TPU masking filter, it was found that the penetration of oil mist lower than 300 nm can be suppressed. To further study the performance of TPU masking filter, we create different melt-spun TPU filters with different fiber diameter and packing density. The performance on the oil mist filtration will be presented in detail. Its contribution and effectiveness to the lifetime extension of a standard PP electrostatic filter will also be discussed.

Particulate removal characteristics of pilot scale two stage vortex wet scrubber system

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Abstract:

Concern on the environmental and health effects of fine particles has led to tightening of pollution control regulations world wide. Many applications that have provided adequate level of particle mass removal are now facing problems with fine and submicron particles. Wet scrubbers have been popularly used for the collection of acidic gases, mists, and particles with significantly reducing risks of fire, explosion and erosion. However, The removal efficiency of fine particles in wet scrubbers is typically very low so they will not meet the requirements of new pollution prevention standards. The particulate removal efficiency of wet scrubbers can be increased by additional cleaning devices, like ESP or by using high energy venture scrubbers. This would mean a high increase in the initial installation and operational costs.

In this study, we developed the pilot scale two stage vortex wet scrubber system to achieve high particulate removal efficiency while minimizing maintenance costs. There are deflectors in two stage vortex wet scrubber to create turbulence by passing the gas at relatively high velocities through the nozzle. The curved baffle causes the water to fall back like waves leading to turbulence in the water column within the inner compartment. Therefore, the pilot scale two stage vortex wet scrubber system is simple in operation and represents high performance with no additional electrostatic force. The fly-ash was used as test dust and the particle concentrations were measured with a portable laser aerosol spectrometer (Model 1.108; Grimm GmbH., Germany). The mean particle size of test dust was 3.7 μm . Results from the test exhibit a high particulate removal efficiency of above 98%.

Keywords: Wet scrubber, pressure drop, particulate matter, removal efficiency, fly-ash

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The effect of filter outside air-blowing cleaning on the fabric filter contaminated by submicron particle

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Jong-Sang Youn, Inhwan Oh, Ki-Joon Jeon, Thihoangyen Le, Yong-Won Jung, Inha University

Abstract:

This study investigates the new air-blowing cleaning system that directly injects compressed air to the filter surface for filter regeneration in a fabric filter (FF) dust collector. A pilot-scale FF is designed to test the new system as well as the conventional pulse-jet cleaning system on the filter clogging problem by fume particles. The FF has a pleated filter with its filtration area of 2.4 m² and a steel wire installed thermal metal spraying gun was used to supply the fume particles. Differential pressure and particle emission concentration are monitored to examine the effect of the new system on filter regeneration and filtration efficiency. The results show that the air-blowing cleaning is very effective for filter regeneration, which allows the FF to operate stably for a long time whereas the pulse-jet method did not solve the filter clogging problem resulting in the continuously increase of pressure drop. In addition, it has a better performance in decreasing the outlet concentration than pulse-jet cleaning. The air blowing system is expected to provide one promising solution to the FF with clogging problem resulting from fume particles.

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (NRF-2017R1C1B1008811)

Parallel Oral Session VIII

Lecture Theatres of 4/F, Yeung Kin Man Academic Building, City University of Hong Kong

30 May 2019 (Thursday) | 16:00 – 18:00

Topic & Co-chair(s)	Speaker	Title	Presentation Time	Venue
VOC and secondary precursors (3) Co-chair(s) 1. Theodora Nah, City University of Hong Kong 2. He Xiao, The Hong Kong University of Science and Technology	Lin Wang, Fudan University (<i>KC Wong Foundation Invited Speaker</i>)	Highly oxygenated molecules and new particle formation in Linzhi, Tibet	16:00-16:30	Mr and Mrs Lau Tat Chuen Lecture Theatre (LT-5)
	Theodora Nah, City University of Hong Kong	Real-time measurements of gas-phase organic acids using SF ₆ -chemical ionization mass spectrometry	16:30-16:45	
	He Xiao, The Hong Kong University of Science and Technology	Qualitative and exhaustive analysis of oxygenated aromatic compounds in the ambient and biomass burning source organic aerosols using ultra-high-resolution mass spectrometry	16:45-17:00	
	Song Guo, Peking University	Secondary Organic Aerosol Formation from Biomass Burning by using a Potential Aerosol Mass (PAM) Reactor	17:00-17:15	
	Ran Zhao, University of Alberta	Aqueous-phase Processing of SOA Components - Investigations Using Synthesized Chemicals	17:15-17:30	
	Yan Tan, The Hong Kong Polytechnic University	Characterization of products in an environmental chamber for Mixtures of Isoprene/Ozone and Isoprene/Ozone/Nitrogen Dioxide	17:30-17:45	
	Narcisse Tsona, Environment Research Institute	Sulfuric acid formation from SO ₂ oxidation initiated by the superoxide ion	17:45-18:00	
Urban aerosol and air quality (4) Co-chair(s) 1. Min Ju Yeo, Ewha Womans University 2. Amos P. K. Tai, The Chinese University of Hong Kong	Jay Turner, Washington University in St. Louis	Fine Particulate Matter Polyaromatic Hydrocarbons in Ulaanbaatar, Mongolia	16:00-16:15	Chan Kei Biu Lecture Theatre (LT-6)
	Ari Leskinen, Finnish Meteorological Institute	Black and brown carbon concentrations and particle size distributions during a one-year measurement campaign in Southern China	16:15-16:30	
	Zhijun Wu, Peking University	The impacts of SO ₂ and NO _x emissions reduction on atmospheric aerosol chemistry in a megacity, Beijing, China	16:30-16:45	
	Min Ju Yeo, Ewha Womans University	Trend and status of the air quality in North Korea	16:45-17:00	
	Ka Fung Leung, The Hong Kong University of Science and Technology	Decadal trend of biomass burning contribution towards PM _{2.5} in Pearl River Delta region as tracked by levoglucosan	17:00-17:15	
	Amos P. K. Tai, The Chinese University of Hong Kong	Intercropping as a sustainable farming method to safeguard both Chinese food security and particulate matter air quality	17:15-17:30	
Aerosol chemistry (6) Co-chair(s) 1. Weijun Li, Zhejiang University 2. Yongjie Li, University of Macau	Xiaohong Yao, Ocean University of China, (<i>KC Wong Foundation Invited Speaker</i>)	Enhanced formation of ammonium nitrate and aminium nitrate in the thin air	16:00-16:30	SAE Magnetics Lecture Theatre (LT-9)
	Jihoon Seo, Korea Institute of Science and Technology	Effects of long-range transport on the nitrate aerosol formation in Seoul, South Korea	16:30-16:45	
	Zhirong Liang, Hong Kong Polytechnic University	Characterisation of SVOCs from Fuel, Lubricant and Diesel Engine Emissions Utilizing GC×GC-ToF-MS	16:45-17:00	
	Chunlei Cheng, Jinan University	Mixing state of oxalic acid containing particles in the rural area of Pearl River Delta, China: implications for the formation mechanism of oxalic acid	17:00-17:15	
	Ruifeng Zhang, City University of Hong Kong	Heterogeneous Oxidation of SO ₂ by Nitrate Photolysis at 300nm	17:15-17:30	
	Tianzeng Chen, Chinese Academy of Sciences	Enhancement of aqueous sulfate formation by the coexistence of NO ₂ /NH ₃ under high ionic strengths in aerosol water	17:30-17:45	
	Chia C. Wang, National Sun Yat-sen University	Valence Electronic Properties and Interfacial Solvation of Phenolic Aqueous Nanoaerosols Probed via Aerosol VUV Photoelectron Spectroscopy	17:45-18:00	
Special symposium: Aerosol mass spectrometry (3) Co-chair(s) 1. Qi Chen, Peking University 2. Hiroyuki Hagino, Japan Automobile Research Institute	Nga Lee Ng, Georgia Institute of Technology (<i>Invited Speaker</i>)	Organic Aerosol Composition in the Southeastern United States: the Role of Organic Acids	16:00-16:30	Peter Ho Lecture Theatre (LT-10)
	Hiroyuki Hagino, Japan Automobile Research Institute (<i>Invited Speaker</i>)	Rapid and sensitive direct analysis of multi-elements in aerosol by ICP-TOFMS	16:30-17:00	
	Qi Chen, Peking University (<i>Invited Speaker</i>)	Sources of Secondary Aerosol Species in a Polluted Urban Environment: Insights from Concurrent Composition Measurements for PM ₁ and PM _{2.5}	17:00-17:30	
	Jianzhong Xu, Chinese Academy of Sciences	Chemical characterization of PM ₁ from highland barley burning emission in the northeastern Qinghai-Tibet Plateau	17:30-17:45	

	Wei Chen, Chinese Academy of Sciences	Source and mixing state of atmospheric particles in an urban area of Guangzhou, China	17:45-18:00	
Aerosol instrumentation (2) Co-chair(s) 1. Jonathan Symonds, Cambustion 2. Cheng WU, Jinan University	Jingkun Jiang, Tsinghua University (<i>KC Wong Foundation Invited Speaker</i>)	Measuring aerosol size distribution down to 1 nm: recent progresses and atmospheric applications	16:00-16:30	Jennifer and Haywood Cheung Lecture Theatre (LT-13)
	Ya-Hsuan Liu, National Central University	DMA hyphenated with sp ICP-MS for characterizing atmospheric aerosols	16:30-16:45	
	Krag Petterson, Cooper Environmental	Use of a Quantitative Reference Aerosol to Validate the Measurement Accuracy of Near Real Time XRF Based Metals Monitors	16:45-17:00	
	Jonathan Symonds, Cambustion	Continuous Scanning of the Aerodynamic Aerosol Classifier	17:00-17:15	
	Paap Koemets, University of Tartu / Airel Ltd.	Using an X-ray Source for Bipolar Particle Charging in the Neutral cluster and Air Ion Spectrometer	17:15-17:30	
	Huang Zhang, Washington University in St. Louis	Numerical modeling to investigate the performance of high flow DMAs to classify sub-2 nm particles	17:30-17:45	
	Nghiem Thi-Thuy Nguyen, National Chiao Tung University	Semi-dry Electrostatic Precipitator (SDEP) Based Systems for Real-time Monitoring of PM2.5 Precursor Gases, Inorganic Ions and Metals	17:45-18:00	
Aerosol modelling (1) Co-chair(s) 1. Nicky Yun Fat Lam, City University of Hong Kong 2. Tian Feng, Institute of Earth Environment, CAS	Nicky Yun Fat Lam, City University of Hong Kong	Impact of Tropospheric Downwash on Pearl River Delta Air Quality during Southeast Biomass Burning	16:00-16:15	Leung Ko Yuk Tak Lecture Theatre (LT-14)
	Tian Feng, Institute of Earth Environment, CAS	Secondary organic aerosol enhanced by increasing atmospheric oxidizing capacity in Beijing-Tianjin-Hebei (BTH), China	16:15-16:30	
	Francesco Lucci, Philip Morris International R&D	Consistent modeling approach for multispecies aerosol formation using sectional and moment methods in AeroSolved	16:30-16:45	
	Xiaoyan Ma, Nanjing University of Information Science and Technology	Aerosol physical and chemical properties and their impact on radiation over East Asia	16:45-17:00	
	Xinghong Cheng, Chinese Academy of Meteorological Sciences	An assimilation method of lidar data based on CRTM and WRF-Chem model and its application to PM2.5 forecasting over the Beijing-Tianjin-Hebei Region	17:00-17:15	

Highly oxygenated molecules and new particle formation in Linzhi, Tibet

Lin Wang

Fudan University

Lei Yao, Fudan University

Abstract:

Highly Oxygenated Molecules (HOMs) with low and extremely-low volatility are crucial in new particle formation (NPF) and the subsequent growth of newly formed particles in a pristine atmosphere. To investigate the chemical composition and potential sources of neutral and naturally-charged HOMs and their contribution to NPF, a field campaign was conducted from July to September, 2016 in Linzhi station (29°45'56"N, 94°44'18"E), Tibet Plateau. A nitrate-based chemical ionization -atmospheric pressure interface – time-of-flight mass spectrometer (CI-API-TOF), an atmospheric pressure interface – time-of-flight mass spectrometer (API-TOF), a proton transfer reaction - mass spectrometer (PTR-MS), and an aerosol chemical speciation monitor (ACSM) were deployed to detect HOMs, their potential volatile organic compound (VOC) precursors, and chemical composition of submicron particles, respectively. Our results show that the formation of HOMs was favored with high O₃ concentration, low relative humidity and intense radiation. Dimer and trimer of HOMs were higher in day time than that in night time. During our campaign, high concentrations of O₃, OH radical and VOCs with low concentrations of NO_x that can terminate the autoxidation processes of RO₂ radicals were conducive to the generation of dimers and trimers of HOMs in the daytime. Nonetheless, at nighttime, low concentrations of O₃ along with high relative humidity suppressed the formation of dimers and trimers of HOMs. Meanwhile, organic compounds were dominant in submicron particles, illustrating that organic compounds (most likely HOMs) play crucial roles in particle growth.

Real-time measurements of gas-phase organic acids using SF₆- chemical ionization mass spectrometry

Theodora Nah

City University of Hong Kong

Yi Ji, Georgia Institute of Technology

David Tanner, Georgia Institute of Technology

Hongyu Guo, Georgia Institute of Technology

Amy Sullivan, Georgia Institute of Technology

Nga Lee Ng, Georgia Institute of Technology

Rodney Weber, Georgia Institute of Technology

L. Gregory Huey, Georgia Institute of Technology

Abstract:

The sources and atmospheric chemistry of organic acids are currently poorly understood due in part to the limited range of measurement techniques available. In this work, we evaluated the use of SF₆- as a sensitive and selective chemical ionization reagent ion for real-time measurements of gas-phase organic acids. Field measurements are made using a chemical ionization mass spectrometer (CIMS) at a rural site in Yorkville, Georgia from September to October 2016 to investigate the capability of this measurement technique. Our measurements demonstrate that SF₆- can be used to measure a range of organic acids in the atmosphere. 1-hour averaged ambient concentrations of organic acids ranged from a few parts per trillion by volume (ppt) to several parts per billion by volume (ppb). All the organic acids displayed similar strong diurnal behaviors, reaching maximum concentrations between 5 and 7 pm local time. The organic acid concentrations are dependent on ambient temperature, with higher organic acid concentrations being measured during warmer periods. Overall, our results show that the SF₆- CIMS method is a promising technique for the real-time measurement of ambient gas- and particle-phase organic acids.

Qualitative and exhaustive analysis of oxygenated aromatic compounds in the ambient and biomass burning source organic aerosols using ultra-high-resolution mass spectrometry

HE Xiao

The Hong Kong University of Science and Technology

MA Yingge, Shang Hai Academy of Environmental Science

LI Xiaojing, Shang Hai University

YU Jianzhen, The Hong Kong University of Science and Technology

Abstract:

Organic fractions of the atmosphere aerosols vary extensively from the micro molecular structures to macroscale chemical and physical properties. Over the past decades of fast development of instrumentation in atmospheric chemistry field, the new generation of ultra-high-resolution mass spectrometers (UHRMS) has dramatically improved our ability to identify organic compounds even without the presence of external standards. The HUmic-Like Substances (HULIS) fraction (water extraction), methanol extraction, and DCM extraction isolated from aerosol samples collected at a suburban site in Hong Kong as well as biomass burning (i.e., sugarcane and rice) sources were analyzed using Orbitrap MS coupled with a soft electrospray ionization source in positive and negative modes. Benefiting from the remarkable resolving power and mass accuracy, thousands of peaks were identified and assigned unambiguous molecular formulas. Compounds that have aromatic index (AI) larger than 0.5, or double bond equivalent (DBE) larger than 4, are likely to bear an aromatic moiety. They were of preferential interests and further investigated. A self-developed multi-dimensional Kendrick Mass Defect (KMD) framework is applied to conduct a holistic study on the distribution of organic oxygenated aromatic compounds in ambient and biomass burning source aerosols.

Secondary Organic Aerosol Formation from Biomass Burning by using a Potential Aerosol Mass (PAM) Reactor

Song Guo

Peking University

Hui Wang, Peking University

Kai Qiao, Peking University

Wenting Chen, Peking University Shenzhen Graduate School

Weizhao Xu, Peking University

Liwu Zeng, Peking University Shenzhen Graduate School

Xiaofeng Huang, Peking University Shenzhen Graduate School

Lingyan He, Peking University Shenzhen Graduate School

Min Hu, Peking University

Zhijun Wu, Peking University

Abstract:

The oxidation of biomass burning emission is one of the important contributors to secondary organic aerosol (SOA). However, models based on laboratory-measured SOA yields fail to fully explain the ambient observations. In this study the oxidation of wheat straw burning emissions was investigated by connecting a new potential aerosol mass (PAM) reactor with Biomass Burning Simulation System at Peking University Shenzhen Graduate School. A sheath flow was used surrounding the sample flow to reduce wall loss. OH exposure was provided by the reaction of O₃ and H₂O at light wavelength of 254 nm. Several condition experiments were conducted to optimize the experiments. A sheath flow (2lpm) to sample flow (8lpm) ratio of 2:8 was used in the experiment with a lowest wall loss of ~20%. Experiments consist of passing diluted emissions through a PAM reactor over integrated OH exposures ranging from ~0 to 23 hours of equivalent atmospheric oxidation. Our results indicated that water content of biomass and burning phase have great impact on SOA formation potential, represented by OA enhancement (defined as oxidized OA/primary OA). OA enhancement in flaming phase has no significant increase. While in smoldering phase it is ~5 times when water content is 5% and ~15 times when water content is 15%, respectively. f₄₄ rises as the oxidation level grow higher. However, f₆₀ changes reversely. O:C changes from ~0.2 at lowest OH exposures to ~0.5 at highest OH exposures.

Higher moisture in straw and smoldering stage cause larger OA enhancement, which may be accounted for more VOCs in those conditions. SOA formation potential in all operation conditions ranges from 2.03

to 3.04. This is first time to study SOA formation potential of different burning phase using PAM in China, which can be an example for other sources SOA formation potential study in the future.

Aqueous-phase Processing of SOA Components - Investigations Using Synthesized Chemicals

Ran Zhao

University of Alberta

Jessica Lima Amorim, University of Alberta

Christopher Kenseth, California Institute of Technology

Yuanlong Huang, California Institute of Technology

Nathan Dalleska, California Institute of Technology

Florence Williams, University of Alberta

John Seinfeld, California Institute of Technology

Abstract:

Atmospheric aqueous phases (cloud, fog, and aerosol liquid water) are important reaction media for organic compounds. Water-soluble species can dissolve or partition into the aqueous phase and are processed by aqueous-phase chemistry. A major challenge for laboratory investigation is a lack of commercially available standards, which has restricted the number of atmospherically relevant compounds studied thus far. In this talk, we present two projects using organic compounds synthesized in our laboratories. The first set of experiments focuses on pinic acid, one of the dominant components of monoterpene SOA. Our study represents the first systematic investigation for the OH reactivity and reaction mechanism of pinic acid in the aqueous phase. The second set of experiments focuses on α -hydroxyacyl hydroperoxides (α -AAHPs), a class of ester hydroperoxides arising from the reactions between Criegee intermediates and organic acids. We found that α -AAHPs undergo rapid hydrolysis in the aqueous phase. Overall, we demonstrate that chemical synthesis opens avenues for novel findings in understanding the atmospheric fate of important SOA components.

Characterization of products in an environmental chamber for Mixtures of Isoprene/Ozone and Isoprene/Ozone/Nitrogen Dioxide

Yan TAN

PolyU

Abstract:

Biogenic volatile organic compound (BVOC) is a kind of volatile organic compound which emits into atmosphere from plants sources, and the emission of BVOC shows the key process of influencing the properties of atmospheric environment. As the most abundant hydrocarbon in global atmosphere except methane, isoprene (2-methyl-1,3-butadiene, C₅H₈) readily reacts with hydroxyl radicals (OH), nitrate radicals (NO₃) and ozone (O₃) due to its two double bonds. Because of its high emitted concentration and strong chemical reactivity, isoprene plays an important role in troposphere. A series of gas phase products are found from the reactions. The objective of this paper is: 1) To identify the gaseous products formed during isoprene dark ozonolysis; 2) To investigate how the various conditions like different NO₂ concentration and humidity will affect the formation of OVOCs.

The environmental chamber is located in the Hong Kong Polytechnic University (PolyU). The chamber is composed of stainless steel plate and teflon bag. All the reactions occur within the 0.005'' thick teflon PFA bag. The volume of the teflon bag is 6m³ i.e. 2 m (Length) x 2 m (Width) x 1.5 m (Height) and the surface-to-volume ratio of the bag is 3.3 m⁻¹. The temperature and relative humidity of total chamber system is controllable, which can be set to 10~40 ±1 °C and 5~90%, ±3% RH, respectively.

The VOCs were analyzed by Proton Transfer Reaction Time of Flight Mass Spectrometry (PTR-TOFMS, IONICON, Innsbruck, Austria). The particle size distributions were analyzed by Scanning Mobility Particle Sizers (SMPS, TSI 3080, TSI Inc., America). The concentration of NO_x and O₃ was detected by NO_x analyzer and O₃ analyzer respectively. The concentration of N₂O₅ was detected by chemical ionization mass spectrometry (CIMS).

C₁-C₄ OVOC species can be detected by the PTR-TOFMS in real time during the reaction between isoprene and O₃ (Fig. 3). The concentration of CH₂O, CH₂O₂ and C₄H₆O increased exceedingly at the end of the reaction. It is obvious that oligomerization occurred to a fraction of first-generation products. These major OVOCs species were C₁~C₄ OVOCs and could be classified into aldehyde, ketone, and acid (or ester), which summarized in Table 2.

C₄H₆O, including methacrolein (MACR) and methyl vinyl ketone (MVK), was the major gaseous product observed in the experiment under condition of low NO₂ concentration. Formaldehyde (HCHO) was the second major gaseous product. With the presence of NO₂, the yields of all OVOC species decreased, especially for C₄H₆O, C₄H₆O₂, C₃H₆O, and CH₂O₂, implying that NO₂ has a negative effect on the generation of OVOCs.

Comparison of final OVOC concentrations obtained under super dry (<5% RH) and humid (56%) condition shows in Fig 5. The concentrations of all investigated OVOCs were depressed under the humid condition. It illustrates that the concentration of formaldehyde (HCHO) decreased obviously under the humid condition. The hydrophilicity of formaldehyde (HCHO) might result in its the adsorption and transformation from gas phase to particle phase.

Sulfuric acid formation from SO₂ oxidation initiated by the superoxide ion

Narcisse Tsona

Environment Research Institute, Shandong University, China

Lin Du, Environment Research Institute, Shandong University, China

Abstract:

Climate change is currently one of the central scientific issues in the world, and the ability to reliably forecast climate is crucial for making political decisions that affect the lives of billions of people. Aerosols remain the dominant uncertainty in predicting radiative forcing and future climate change. One of the least understood aerosol-related processes is nucleation: the formation of new particles from condensable vapors. A high proportion of aerosol particles is formed from SO₂ reactions in the gas-phase, through the formation of sulfuric acid (H₂SO₄). While nucleation is related primarily to neutral clusters, state-of-the-art experimental methods measure only charged clusters.

There has also been strong evidence that the contribution of ions to aerosol formation is non-negligible. Motivated by this, many ion-catalyzed SO₂ oxidation mechanisms have been investigated in order to find the connectivity between the missing H₂SO₄ and H₂SO₄ formed from ion-catalyzed SO₂ oxidation. For example, different combined theoretical studies showed that SO₂ oxidations initiated by O₃⁻ and SO₄⁻ ultimately lead to the formation of H₂SO₄, in the mechanisms where each of the ion acts as a catalyst in the following reaction: SO₂ + O₃ → SO₃ + O₂. SO₃ is a precursor for H₂SO₄.

One oxidation mechanism, initiated by the superoxide ion (O₂⁻), is explored in this research. It was previously shown that O₂⁻ reacts readily with SO₂ to form a peroxy form of compound, O₂SOO⁻, whose atmospheric fate is currently unclear. However, any atmospheric sulfur-containing compound is susceptible to significantly alter the formation mechanism of aerosol particles.

The main objective of this study is to explore the chemical outcome of O₂SOO⁻ by collision with relevant atmospheric species, namely NO_x and O₃, which will most likely terminate the oxidation of SO₂ initiated by O₂⁻. We assess the importance of these reactions in aerosol formation, using quantum chemical calculations and statistical thermodynamics. Special focus is given to the mechanisms underlying the formation of H₂SO₄, hereby (partially) accounting for the missing H₂SO₄ needed to fully explain the observed atmospheric particle formation rates.

Reaction mechanisms, thermodynamics, kinetics, and the effect of hydration were determined under atmospherically relevant conditions. The main species (SO₃⁻) in the end products of the studied reactions has been proved to form both in the atmosphere and in experiments, where it definitely plays a role in atmospheric sulfur chemistry and particle formation. The contribution of this mechanism to the total atmospheric sulfuric acid formation was estimated to be 0.3 to 3.5% depending to the altitude. The

studied reaction further deepens the understanding of ion-induced SO₂ oxidation, with implications in aerosol formation.

Fine Particulate Matter Polyaromatic Hydrocarbons in Ulaanbaatar, Mongolia

Jay Turner

Washington University in St. Louis

Skyler Simon, Washington University in St. Louis, St. Louis, MO/USA

Audrey Dang, Washington University in St. Louis, St. Louis, MO/USA

Jay Turner, Washington University in St. Louis, St. Louis, MO/USA

Rufus Edwards University of California at Irvine, Irvine, CA/USA

Brent Williams Washington University in St. Louis, St. Louis, MO/USA

Abstract:

Ulaanbaatar, the capital of Mongolia, is commonly ranked among the worst cities in the world for outdoor particulate matter (PM) air pollution. Air quality conditions are particularly poor during the wintertime because of the extreme climate and high demand for energy to satisfy space heating needs. Coal combustion by combined heat and power utility plants, heat-only boilers, and residential stoves dominate the wintertime PM emissions, with additional contributions from motor vehicles. A detailed analysis of organic PM composition is being conducted with an initial focus on polyaromatic hydrocarbons (PAH). Archived PM_{2.5} samples, collected on quartz filters at four sites in Ulaanbaatar from January to April 2013, were analyzed by thermal desorption GCMS. Twelve PAH compounds have been quantified to date with plans to quantify additional PAH compounds not included in the calibration standard. Total mass concentration of the 12 PAH compounds exceeded 2.5 µg/m³ for two 24-hour sampling periods during January at one of the sites. Both total PAH mass concentration as well as overall carcinogenic PAH relative potency (cPAH RP) decreased from January to April as temperatures warmed, coal burning declined, mixing layers increased in depth, and partitioning to the gas phase was favored. The relative abundance of PAH compounds shifted upon the transition from winter to spring with a dramatic decrease in low molecular weight compounds such as phenanthrene. Positive Matrix Factorization (PMF) yielded a three-factor solution; interpretation of the factors is pending. Current data analyses focus on PAH spatial variability and future work will focus on quantifying additional non-PAH organic molecular markers and also air toxics metals being analyzed by ICP-MS.

Black and brown carbon concentrations and particle size distributions during a one-year measurement campaign in Southern China

Ari Leskinen

Finnish Meteorological Institute

Antti Ruuskanen, Finnish Meteorological Institute

Xiao-Wen Zeng, Sun Yat-Sen University

Guang-Hui Dong, Sun Yat-Sen University

Mika Komppula, Finnish Meteorological Institute

Abstract:

Aerosol size distribution and black carbon (BC) concentration were measured between August 2017 and November 2018 in the cities of Guangzhou and Maoming, which is about 300 km south-west of Guangzhou, in China. The measurements were made on the roof of buildings at about 40 m above the street level. At both sites the size distribution (divided into 22 size bins) of 10 nm – 2.5 µm particles was measured with a TSI 3910 Nanoparticle Sizer and a TSI 3330 Optical Particle Sizer. The BC concentration and aerosol light absorption coefficient were measured with a Magee Scientific AE-42 aethalometer at seven wavelengths (370 – 950 nm), which offers a tool to resolve the contribution of brown carbon to light absorption. For all aerosol instruments, the sampling line was equipped with an inlet with a 2.5 µm cut-off size cyclone for better comparison with other PM_{2.5} measurements. Ambient temperature, relative humidity, pressure, rain intensity and duration, as well as wind speed and direction were measured with a Vaisala WXT520 weather station. Air mass backward trajectories were calculated for preceding 120 hours with 1 hour time resolution by using the HYSPLIT model for source analysis.

With this suite of instruments we were able to split the conventional bulk PM_{2.5} into pieces and survey its subfractions (e.g., PM₁, PM_{0.5}, PM_{0.2}) and further on their links to human health in more detail. The time resolution is faster as well (1 min for size distribution, 5 min for BC concentration), compared to filter-based PM_{2.5} measurements whose time resolution is normally 1–24 hours. This enables us to monitor the particle and BC concentrations in fast changing situations and environments.

The impacts of SO₂ and NO_x emissions reduction on atmospheric aerosol chemistry in a megacity, Beijing, China

Zhijun Wu

Peking University

Yu Wang, Peking University

Song Guo, Peking University

Min Hu, Peking University

Abstract:

The sulfur and nitrogen-containing gaseous precursors (such as SO₂ and NO_x) emitted from fossil fuel combustion were transferred into hygroscopic particle constituents (sulfate and nitrate acids or salts) via diverse chemical pathways in the atmosphere. Such atmospheric processes lead to the global environmental issues, such as acidification through wet deposition to ecosystems, air quality degradation and human health, and global climate change. During recent years, China take great efforts on reducing the SO₂ and NO_x emissions. The long-term measurements of aerosol chemistry and the gaseous precursors were carried out since 2004 in the campus of Peking University in the Megacity of Beijing. In this study, trend analyses of the gaseous precursors are performed to track the ambient concentrations of these gaseous precursors respond to changes in emissions. Most importantly, this study will give insight into a historical understanding of the changes in aerosol chemistry. Our results show that the reduction of SO₂ ambient concentrations is significantly, while it is not true for NO_x. As a result, the sulfate in PM_{2.5} decreased significantly, and the fine particles become more nitrate-dominant in the atmosphere of Beijing. As an example, we analyze a typical haze episode occurred in rural site of Beijing in 2016 winter. It was observed that particulate nitrate (pNO₃⁻) accounted for up to 60% of nonrefractory PM₁ mass loading. As RH increases from ~10% to 70%, the water uptake lead to an increase in aerosol surface and volume, hence i) facilitating total nitrate formation through heterogeneous reactions, e.g. N₂O₅ hydrolysis increasing by 50 times and ii) suppressing partial pressure of HNO₃ vapor over particles by a factor of 10~100, facilitating condensation of HNO₃ to pNO₃⁻ during haze episode. The accelerated pNO₃⁻ formation enhances hygroscopicity and enlarges aerosol liquid water, therefore further increases aerosol surface area and volume, which in turn facilitates pNO₃⁻ formation. This self-amplification process can rapidly halve visibility and enhance fine particle concentration within one day. Above analysis gives an explanation why such high nitrate was observed in PM_{2.5} after significant SO₂ emissions reduction.

Trend and status of the air quality in North Korea

Min Ju Yeo

Ewha Womans University

Yong Pyo Kim, Ewha Womans University

Abstract:

Recently, concerns on the air quality in North Korea (NK) have been growing in South Korea (SK). Despite of low level of energy consumption in NK, at about 4% of that in SK in 2014, the emission amounts of particulate matter (PM) and carbon monoxide have been reported to be higher than SK. Furthermore, the mortality rate attributed to household and ambient air pollution in NK was the first in the world in 2012. Also, a few studies suggested that air pollutants in NK could affect the air quality in SK. Thus, it is needed to understand the status of the air quality in NK. In this study, we tried to (1) figure out the trend of PM level in NK, (2) discuss the major factors influencing the emissions of air pollutants in NK, and (3) find ways to improve the air quality in NK.

Decadal trend of biomass burning contribution towards PM_{2.5} in Pearl River Delta region as tracked by levoglucosan

Ka Fung Leung

The Hong Kong University of Science and Technology

Jian Zhen Yu, The Hong Kong University of Science and Technology

Bin Yu Kuang, The Hong Kong University of Science and Technology

Abstract:

Biomass burning is one of the major sources PM_{2.5} in Pearl River Delta (PRD) region and many other places in the world. Despite numerous studies on PM_{2.5} source apportionment in PRD region, long-term study of the changes of contribution by biomass burning is non-existent. In this work, we measured concentrations of levoglucosan, a unique tracer of biomass burning, at three sampling sites in PRD region (Guangzhou, Nansha and Tsuen Wan (TW)) from 2008 to 2017, and examined seasonal variations and decadal trends of biomass burning activities using data at TW. The data shows slightly decreasing trend with a slope of $-3.07 \text{ ng m}^{-3} \text{ yr}^{-1}$. The average levoglucosan concentration in winter (101 ng m^{-3}) is higher than that in summer (28 ng m^{-3}) by 3.7 times. Ratio-ratio plots of levoglucosan/mannosan (L/M) vs levoglucosan/water-soluble potassium (L/K+) are used to aid the identification of major contributing biomass burning types. The plots reveal that biomass burning sources impacting TW are mainly associated with burning crop residue and grass, which is a result of regional transport from Mainland China due to the prevailing northerly winds in winter. However, in late August in Hong Kong, people burn incense and joss paper in the Hungry Ghost Festival (Yulan Festival), resulting in particularly high levoglucosan concentrations during those days. This annual local biomass burning source is responsible for the five highest concentrations during the 10-year period. The median concentration of levoglucosan in winter is higher than that in summer, by 12.3 times ($82 \text{ vs } 6.7 \text{ ng m}^{-3}$), reflecting the significant contribution of regional transport. Decreasing trends of biomass burning at the other two sites are also observed, due to reduction in relate burning activities.

Intercropping as a sustainable farming method to safeguard both Chinese food security and particulate matter air quality

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Ka Ming Fung, Hon-Ming Lam

Abstract:

Large-scale, industrialized farming has contributed significantly to the increased global food supply to feed the fast-growing world population over the past few decades, but it also comes with severe threats to the environment. In particular, the excessive application of chemical fertilizer has led to large emissions of reactive nitrogen compounds into the atmosphere, where they become significant components of fine particulate matter (PM_{2.5}) air pollution. Intercropping has been considered as a sustainable agricultural practice that can reduce the environmental impacts of agriculture, but its potential benefits beyond the farm scale have rarely been examined. Here we develop a new parameterization scheme for belowground mutualistic interactions between intercropped crops in the DeNitrification-DeComposition (DNDC) biogeochemical model, which is then used to simulate and quantify the benefits of nationwide adoption of maize-soybean systems in China in terms of gains in crop production, decreases in fertilizer consumption, and reductions in ammonia (NH₃) emission. We further examine how such a decline in NH₃ emission could lessen the downwind formation of PM_{2.5} using the GEOS-Chem chemical transport model. We show that annual mean inorganic PM_{2.5} concentrations can be reduced by up to 1.5 $\mu\text{g m}^{-3}$ with the nationwide adoption of maize-soybean intercropping, with a corresponding annual net economic benefit of US\$67 billion, of which US\$13 billion arises from saved health costs from reduced air pollution. This study demonstrates the economic and environmental values of intercropping systems in dually promoting food security and environmental health, which can serve as a basis for policy consideration as governments and stakeholders explore more sustainable farming options.

Enhanced formation of ammonium nitrate and aminium nitrate in the thin air

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Abstract:

Formation of ammonium nitrate and aminium nitrate has been widely studied in the air at 1 atm. From the ground level to the passenger flight flying height, atmosphere pressure decreases by approximately 90%. What happens for formation of nitrate salt aerosols in diluted airplane plumes at the height? With decreasing atmosphere pressure, the conventional thermodynamic theory suggests less amount of these aerosols to be formed.

In this study, we find that the formation theory of nitrate salt aerosols at 1 atm cannot explain their gas-particle formation in the thin air. We create the thin air condition using a nano-MOUDI sampler, where a large pressure drop exists from the inlet to the last impactor in sampling. Under the pressure down to 0.6-0.1 atm, the formation of ammonium nitrate and aminium nitrate gets largely enhanced and their yields are several times to one order of magnitude larger than that at 1 atm. We examine the enhancement mechanism using the diluted combustion plumes and ambient air. When the ambient air was used to examine, the enhancement can be observed only in winter under freezing conditions. Enhanced formation of ammonium nitrate and aminium nitrate in the thin air should be considered in the future since there are large amounts of air pollutants emitted from passenger flights.

Effects of long-range transport on the nitrate aerosol formation in Seoul, South Korea

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Abstract:

Air quality in Seoul, one of the highly populated megacities in East Asia, is not only affected by local emission sources but also episodic long-range transport of air pollutants from China. Although severe haze episodes in Seoul are regarded as a result from the combined effect of local and remote sources, the detailed chemical mechanisms of the particle formation are still in vague. In this study, we explored the role of aerosol water content (AWC) and temperature related to the long-range transport condition in nitrate partitioning by utilizing daily PM_{2.5} chemical composition data in Seoul between 2012 and 2014 and the ISORROPIA II thermodynamic model. Using the HYSPLIT backward trajectories, we classified sampling dates into the local source case, remote source case, and combined source case based on the average residence time of air mass in China (North China Plain and Yangtze River Delta) and in the Seoul Metropolitan Area. Our results show that the remote source and combined source cases are characterized by inorganic-rich wet particles while the PM_{2.5} samples during the local source case are organic-rich and less AWC. In terms of meteorological conditions, temperature during the remote source and combined source cases are generally lower than the local source case because the long-range transport from China occurs in the cold season. The nitric acid–nitrate partitioning analysis based on the thermodynamic model results for different cases reveals that the synergistic effects of lower temperature and higher AWC induce more nitrate uptake during the combined source cases.

Characterisation of SVOCs from Fuel, Lubricant and Diesel Engine Emissions Utilizing GC×GC-ToF-MS

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Hai Guo, Hong Kong Polytechnic University

Abstract:

There are uncertainties regarding the composition of vehicular particulate emissions. Some of these uncertainties are attributed to the limited knowledge relating to the composition of semi-volatile organic compounds (SVOC). SVOC partition between the gas and particulate phase and can have adverse effects on human health and environment. Using comprehensive gas chromatography (GC) coupled to variable electron ionisation time-of-flight mass spectrometry (ToF-MS), the composition of engine SVOC emissions are investigated; identifying a wealth of homologous series from within the unresolved complex mixture (UCM) of the chromatogram.

Fuel and engine lubricating oil are major contributors to engine SVOC emissions. The composition of diesel fuel and engine lubricating oil were investigated. The gas and particulate phase SVOC emissions from a light-duty diesel engine were identified and attributed to originate from the fuel and/or oil. Engine emission samples were collected, at steady state conditions, before and after the diesel oxidation catalyst (DOC) from the exhaust of a 2.2 L four-cylinder diesel engine. Engine exhaust was diluted with clean ambient air and collected using both adsorption tubes and filters, for gas and particulate phase species respectively. Samples were subsequently analysed using thermal desorption (TD)-GC×GC-ToF-MS. Particulate number and size distribution was investigated using a CAMBUSTION DMS500 fast particulate analyser.

A quantification technique for SVOC was developed based on the relation of total ion current to molar quantity or mass. The composition of diesel fuel was dominated by compounds of < C₂₀. The analytical results demonstrate that high molecular weight alkanes (C₂₅-C₃₂) are present in abundance in the lubricating oil. Differences in composition of engine exhaust before and after the DOC are presented. Compounds identified from the engine exhaust contained n- and branched alkanes, alkyl-cycloalkanes, alkyl-benzenes, various aromatics and polycyclic aromatic hydrocarbons (PAH). Gas phase engine SVOC emissions were similar to those characterised in the fuel (<C₂₀), whereas particulate phase engine SVOC emissions were similar to compounds identified in the engine lubricating oil. These results obtained exemplify the complexity of SVOC emissions from vehicular exhaust emissions.

Mixing state of oxalic acid containing particles in the rural area of Pearl River Delta, China: implications for the formation mechanism of oxalic acid

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Yangxi Chu, City University of Hong Kong

Zhen Zhou, Jinan University

Abstract:

Particulate amines play an important role for the particle acidity and hygroscopicity and also contribute to secondary organic aerosol mass. We investigated the sources and mixing states of particulate amines using a single-particle aerosol mass spectrometer (SPAMS) during summer and winter 2014 at a rural site in the Pearl River Delta, China. Amine-containing particles accounted for 11.1 % and 9.4 % of the total detected individual particles in summer and winter, respectively. Among the three markers we considered, the most abundant amine marker was $74(\text{C}_2\text{H}_5)_2\text{NH}_2^+$, which was detected in 90% and 86% of amine-containing particles in summer and winter, followed by amine marker ions of $59(\text{CH}_3)_3\text{N}^+$, and $86(\text{C}_2\text{H}_5)_2\text{NCH}_2^+$ which were detected in less than 10% of amine-containing particles during sampling period. The amine-containing particles were characterized by high fractions of carbonaceous marker ions, carbon-nitrogen fragments, sulfate and nitrate in both summer and winter. Robust correlations between the peak intensities of amines and sulfate and nitrate were observed, suggesting the possible formation of aminium sulfate and nitrate salts. Interestingly, only 8% of amine particles contained ammonium in summer, while the percentage increased dramatically to 54 % in winter, indicating a relatively ammonium-poor state in summer and an ammonium-rich state in winter. The total ammonium-containing particles were investigated and showed a much lower abundance in ambient particles in summer (3.6%) than that in winter (32.6%), which suggests the ammonium-poor state of amine-containing particles in summer may be related to the lower abundance of ammonia/ammonium in gas and particle phase. In addition, higher abundance of amines in ammonium-containing particles than that of ammonium in amine-containing particles suggests a possible contribution of ammonium–amine exchange reactions to the low abundance of ammonium in amine-containing particles at high ambient RH (72 ± 13 %) in summer. The particle acidity of amine-containing particles is estimated via the relative acidity ratio (Ra), which is defined as the ratio of the sum of the sulfate and nitrate peak areas divided by the ammonium peak area. The Ra was 326 ± 326 in summer and 31 ± 13 in winter. However, after including amines along with the ammonium in the acidity calculation, the new Ra' values showed

no seasonal change in summer (11 ± 4) and winter (10 ± 2), which suggests that amines could be a buffer for the particle acidity of ammonium-poor particles.

Heterogeneous Oxidation of SO₂ by Nitrate Photolysis at 300nm

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Abstract:

Severe haze events in China have caused adverse effects on air quality and human health in recent years. Sulfate has been found to be a key contributor to the haze events. However, traditional sulfate production pathways, for example, oxidation mechanisms by O₃, H₂O₂ and O₂, cannot adequately explain significantly high concentration of sulfate observed during the haze events. In this study, we propose a much less explored pathway of heterogeneous oxidation reaction of dissolved SO₂ by photolysis of particulate nitrate at 300 nm. We performed reactive uptake experiments of SO₂ by ammonium nitrate (AN) droplets with varying initial particle pH and actinic flux. AN droplets were internally mixed with organic compounds including glyoxal, oxalic acid, L-cysteine, and sodium benzoate as an OH scavenger to study the effect of the presence of organic compounds. In situ Raman spectroscopy was used to quantify the sulfate production. The results show that the sulfate production rate increases with the actinic flux, but the sulfate production is not sensitive to initial particle pH between 0.6 and 4.4. The presence of organic compounds do not significantly inhibit the sulfate production. We speculate the involvement of HO₂ radicals produced from OH and organic compounds in the oxidation of dissolved SO₂. Evidently, the sulfate production rates become lower in N₂ (no HO₂ radical production) than those in air in the presence of organic compounds. The present study provides insight into the current debate on sulfate production mechanisms.

Enhancement of aqueous sulfate formation by the coexistence of NO₂/NH₃ under high ionic strengths in aerosol water

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Hong He, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences

Abstract:

Current air quality models usually underestimate the concentration of ambient air sulfate, but the cause of this underestimation remains unclear. One reason for the underestimation is that the sulfate formation mechanism in the models is incomplete, and does not adequately consider the impact of the synergistic effects of high concentrations of multiple pollutants on SO₄²⁻ formation. In this work, the roles of gaseous NO₂, NH₃ and solution ionic strength in the formation of SO₄²⁻ in the aqueous phase were quantitatively investigated using a glass reactor and a 30 m³ smog chamber, separately. The results showed that SO₄²⁻ formation was enhanced to different degrees in the presence of gas-phase NO₂, NH₃ and their coexistence as solutes in both liquid solution and aerosol water. NH₃ enhances the aqueous oxidation of SO₂ by NO₂ mainly by accelerating the uptake of SO₂ through increased solubility. More importantly, we found that high ionic strength in aerosol water could significantly accelerate the aqueous oxidation of SO₂, resulting in unexpectedly high SO₄²⁻ formation rates. We estimate that under severe haze conditions, heterogeneous oxidation of SO₂ by NO₂ on aerosols may reduce SO₂ lifetime to one seventh of that through gas phase oxidation by OH, aided by high ionic strengths in aerosols. Considering the existence of complex air pollution conditions with high concentrations of NO₂, NH₃ and aerosol water, as expected in typical urban and suburban settings, the SO₄²⁻ formation mechanisms revealed in the present work should be incorporated into air quality models to improve the prediction of SO₄²⁻ concentrations.

Valence Electronic Properties and Interfacial Solvation of Phenolic Aqueous Nanoaerosols Probed via Aerosol VUV Photoelectron Spectroscopy

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Jhih-Hong Huang, Jia-Rong Cai

Abstract:

An in-depth understanding of the fundamental energetic and structural properties at or near the interface of nanoscaled aqueous aerosols is of fundamental and crucial importance in understanding the impacts of organic species, either of biogenic or anthropogenic origins in intervening the cloud formation microphysics and the intrinsic nature of clouds. To address these issues, we applied the recently-developed aerosol VUV photoelectron spectroscopy [1,2] to investigate the valence electronic structures and interfacial characteristics of several organic-containing aqueous nanoaerosols that are of atmospheric significance. Phenol and phenolic compounds represent a major resource of secondary organic aerosols (SOA) in the atmosphere. We applied the recently constructed aerosol VUV photoelectron spectroscopy to investigate for the first time the valence photoelectron spectroscopy of phenol and three dihydroxybenzene (DHB) isomers in the aqueous nanoaerosol form, using the synchrotron-based VUV radiation as the ionization source [3]. By evaluating two photoelectron features of the lowest vertical ionization energies (VIE) originated from the $b_1(\pi)$ and $a_2(\pi)$ orbitals for phenolic aqueous nanoaerosols, their pH-dependent valence electronic structures and interfacial solvation characteristics are unraveled. Both phenol and phenolate are highly surface-active. On the aqueous aerosol interface, they appear only partially solvated, with the hydrophilic $-OH/-O-$ group better immersed in water and the hydrophobic aromatic ring remaining above the interface of aqueous aerosols. Deprotonations of phenolic species accompanying with increasing pH appear to enhance the hydration extent, likely due to the stronger solute-solvent interactions between the negatively charged $-O-$ group and water solvent molecules. A significant fraction of neutral phenol is observed along with phenolate at pH of 12.0, indicating that the chemical composition and surface pH at the aqueous aerosol interface deviate from the bulk. It reveals that the hydration extents, pH values, deprotonation status, and numbers/relative arrangements of $-OH$ groups are crucial factors affecting the ionization energies of phenolic aqueous nanoaerosols and thus their redox-based activities. The multi-faceted implications of the present study in the aerosol science, atmospheric/marine chemistry, and biological science will be addressed.

Organic Aerosol Composition in the Southeastern United States: the Role of Organic Acids

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Masayuki Takeuchi, Georgia Institute of Technology

Theodora Nah, City University of Hong Kong

David Tanner, Georgia Institute of Technology

Hongyu Guo, University of Colorado, Boulder

Amy Sullivan, Colorado State University

Lu Xu, California Institute of Technology

Greg Huey, Georgia Institute of Technology

Rodney Weber, Georgia Institute of Technology

Abstract:

The formation and evolution of secondary organic aerosol (SOA) was investigated at Yorkville, Georgia, southeastern United States, in late summer (mid-August ~ mid-October, 2016). This is a suburban rural site 55km NW of Atlanta, immediately surrounded by forests and open pastures for cattle grazing. The field measurements period was characterized by a transition from summer to fall, where the decreasing temperature has a direct influence on biogenic volatile organic compounds (VOC) emissions and SOA chemistry. A High-Resolution Time-of-Flight Mass Spectrometer (AMS) and a High-Resolution Time-of-Flight Iodide-Adduct Chemical Ionization Mass Spectrometer coupled with a Filter Inlet for Gases and AEROSols (FIGAERO-CIMS) were deployed to characterize submicron particles. A Particle-into-Liquid Samplers coupled with a Dionex ICS-4000 capillary high-pressure ion chromatography (PILS-IC) was deployed to measure water-soluble small organic acids (C1-C5) in submicron particles.

Source apportionment analysis was utilized to identify and quantify organic aerosol (OA) sources. The decreasing isoprene emission throughout the campaign resulted in reduced isoprene-derived SOA formation and changes in isoprene chemistry, posing a challenge to resolving Isoprene-OA factor by unconstrained Positive Matrix Factorization (PMF) analysis. Therefore, Multilinear Engine (ME-2) analysis with constrained Isoprene-OA profiles was applied to the AMS dataset, and resolved four factors, an isoprene-derived SOA (Isoprene-OA), a more-oxidized oxygenated OA (MO-OOA), and two less-oxidized oxygenated OA (LO-OOA1 and LO-OOA2). PMF analysis was applied to the FIGAERO-CIMS dataset and resolved three factors, a more-oxidized day factor (Day_MO OA), a less-oxidized day factor (Day_LO OA) and a night factor (Night OA).

While the measurements, analysis, and source apportionment of AMS and FIGAERO-CIMS data were conducted independently, a strong correspondence is observed between the AMS and FIGAERO-CIMS OA factors, consolidating the results of source apportionments. This good agreement allows better interpretation of OA factors by combining bulk aerosol compositions from the AMS and molecular level information from FIGAERO-CIMS. In addition, remarkable correlations are observed between AMS MO-OOA factor (corresponding to FIGAERO-CIMS Day_MO OA factor) and most of the organic acids measured by PILS-IC, with R^2 ranging from 0.23 to 0.81. The best correlation is between MO-OOA factor and the sum of all the small organic acids ($R^2 = 0.92$), in which oxalate is the most dominant, followed by acetate, succinate, and formate. The strong correlation suggests that particulate organic acids are important components of MO-OOA factor. The FIGAERO-CIMS Day_MO factor is comprised of highly oxidized fragments which are usually identified in aqueous processes. Further, the most abundant condensed-phase organic acid observed, oxalate, has been used as tracer for aqueous-phase chemistry in many studies. Taken together our results suggest that aqueous-phase chemistry is an important source for MO-OOA in southeastern United States.

Rapid and sensitive direct analysis of multi-elements in aerosol by ICP-TOFMS

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Abstract:

Inductively coupled plasma mass spectrometry (ICP-MS) is widely used for the rapid and sensitive detection for a wide range of elements of airborne particles in many applications, such as monitoring of the ambient particulate matter (PM), characterization of emission sources, and maintenance of clean room air for semiconductor manufacture processes. In ICP-MS analysis, aerosols are usually collected on filters and analyzed by pre-processing the resultant sample, known as off-line analysis. This off-line analysis using ICP-MS takes a day to a few days and reduces the time resolution while similar chemical composition and temporal behavior that are characteristic of different sources and/or atmospheric processes. For direct analysis of aerosol samples using ICP-MS, gas exchange devices (GED), which replace air with argon and transport to the instrument, must be equipped to sustain the plasma effects (Nishiguchi et al., 2008). The bulk aerosol gas-converted sample produced by a GED can be introduced directly into the ICP-MS instrument. However, in the ICP-MS using a quadrupole mass spectrometer (ICP-QMS), the signal fine structure was studied in detailed by the scanning-based mass spectrometer; however, simultaneous multi-element detection was not possible. In order to further improve the time resolution of ICP-QMS and to extend its capabilities to determine single particle information, ICP-MS equipped with the time-of-flight mass spectrometer (ICP-TOFMS) was recently developed by Tofwerk and its commercial application was established (icpTOF, Tofwerk). This study describes a rapid and sensitive direct analysis of trace multi-elemental aerosol via ICP-TOF by utilizing a GED (GEDIII, J-Science Laboratory). This presentation shows the field and laboratory deployment of ICP-TOF for multi-element analysis of aerosols by direct measurement with high time resolution and its quantitative ability to detect samples of ambient air or from emission sources.

Sources of Secondary Aerosol Species in a Polluted Urban Environment: Insights from Concurrent Composition Measurements for PM₁ and PM_{2.5}

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Yaowei Li, Peking University

Xi Cheng, Peking University

Ying Liu, Peking University

Tong Zhu, Peking University

John Jayne, Aerodyne Research Inc.

Douglas Worsnop, Aerodyne Research Inc.

Abstract:

Air pollution caused by fine particles is of great concern in megacities because of its significant effects on visibility, radiation, and human health. In recent years, on-line instruments like Aerodyne aerosol mass spectrometer and aerosol chemical speciation monitor are commonly used to characterize the aerosol composition and the sources of organic aerosol (OA) in China. Most of these instruments can only detect the submicron domain. In this study, we deployed a time-of-flight aerosol chemical speciation monitor (TOF-ACSM) equipped with 2.5- μm aerodynamic lens, a capture vaporizer, and a novel sampling-size auto-switching system in Beijing. Non-refractory submicron and fine particles were alternatively detected for every half an hour by the same mass spectrometer under a time resolution of 2.5 min, which allows source apportionments of particles in the two size domains without complications from instrument differences and collection efficiency. No significant differences are discovered between the source apportionments for submicron and fine particles, suggesting good representativeness of previous AMS/ACSM analysis. In winter, for both submicron and fine particles, six factors such as hydrocarbon-like OA, cooking OA, biomass-burning OA, coal-combustion OA and two types of oxidized OA are identified by positive matrix factorization, which is consistent with the findings of previous studies. In summer, four factors including hydrocarbon-like OA, cooking OA, two oxidized OA are identified. One type of the oxygenated OA components is mainly associated with haze events. Submicron particles contribute to the majority (80~90%) of fine-particle mass. The mass ratios of submicron- to fine-mode non-refractory particles and their major chemical components can decrease to about 0.5 during severe haze events, accompanied with high RH. However, the chemical compositions are similar for the two

size domains. Our data suggest that aqueous-phase oxidation or heterogeneous reactions seem not happen fast and locally to produce extra sulfate or SOA during the severe haze events.

Chemical characterization of PM₁ from highland barley burning emission in the northeastern Qinghai-Tibet Plateau

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Abstract:

A field study was carried out at a mountain-top observatory (Waliguan Baseline Observatory, 36.28° N, 100.9° E, 3816 m a.s.l) during June and July 2017 to characterize the chemical characterization of aerosol in the northeastern border of the Qinghai-Tibet Plateau (QTP), where the air mass was frequently influenced by regional air mass transport from low elevated urban areas. During 5 – 6 July 2017, a major Tibetan festival event was occurred on the mountain which was ~1 km northeast of our sampling site. During the festival event, plenty of highland barley mixed with Chinese liquor and other biomass was burned which is a popular manner for local Tibetans to worship the god. The real-time chemical measurements of submicron aerosol (PM₁) was obtained using an Aerodyne high-resolution time-of-flight aerosol mass spectrometer. The mass loading of PM₁ during the festival event occurred from 23:00 on 5 July to 08:00 on 6 July, was ~6 times higher than those before and after the event with an average value of 59.5 $\mu\text{g m}^{-3}$ and dominated by organic aerosol (OA, 73.8%). The sources of OA were studied using positive matrix factorization (PMF) and three components were obtained including a fresh biomass burning OA (BBOA), a traffic-related hydrocarbon-like OA (HOA), and an oxidized OA (OOA) with the average contribution of BBOA and HOA to 45% of total OA, respectively. The chemical characterization and chemical evolution of the BBOA will be discussed in detail which is significant different with the traditional fresh biomass burning emission. These results are important for evaluating and modelling the aerosol radiative forcing, cloud properties and even climate changes in the QTP.

Source and mixing state of atmospheric particles in an urban area of Guangzhou, China

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Abstract:

For Aerodyne aerosol mass spectrometer (AMS) measurement, chemical composition of atmospheric particles and its sources are usually quantified in terms of their bulk properties. With newly developed data acquisition card for fast mass spectra acquisition (ADQ), event trigger mode in AMS can be used to study the source and mixing state of single particles in ambient air. In this study, we performed a field campaign with soot-particle time-of-flight AMS (SP-ToF-AMS) to explore the evolution of aerosol mixing state in an urban area of Guangzhou city in China (autumn 2018). For comparison, a high-resolution time-of-flight AMS (HR-ToF-AMS) was co-sampled with the same inlet. Good agreement on chemical composition from single particle measurement and from bulk mass measurement was found. The source

of single organic aerosol (OA) from K-mean cluster analysis and bulk aerosol results from positive factorization analysis (PMF) will be compared. Further, Size distribution of different OA sources will be demonstrated. difference of mixing state of aerosols under polluted and clean period will be shown. Finally, organic coatings thickness on soot particles as a function of oxidation state of OA will be calculated.

Measuring aerosol size distribution down to 1 nm: recent progresses and atmospheric applications

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Abstract:

Accurate measurement of aerosol size distribution down to ~ 1 nm is a key to understanding the intensive formation of atmospheric new particles. Recent progresses in developing instruments and deploying them in field measurements provides new information about the temporal evolution of atmospheric aerosol size distributions. The performance of electrical-mobility-based aerosol size spectrometer for aerosol size distributions down to 1 nm was significantly improved. The sampling efficiency of a new technique that samples from the core of flow was theoretically quantified using an analytical method. Applying this core sampling technique effectively improves the sampling efficiency of highly diffusive species compared to conventional sampling methods. A new measurement and inversion method based on simultaneous detection of both positively and negatively charged aerosols was proposed to minimize the uncertainties in aerosol charge fraction and hence improve the accuracy of measured aerosol size distributions. A recently developed differential mobility analyzer (DMA) was characterized at typical working conditions. When applied in atmospheric measurements, the high flow rate and high size resolution of this DMA help to reduce the uncertainties. The transmission efficiency through the aerosol sample outlet of a DMA was quantified using a newly proposed analytical model. Accordingly, the sample outlet was redesigned using electrostatic dissipative materials for reducing the adverse electric field and optimizing particle transmission. A new unsheathed particle counter based on two-stage condensational growth was developed and optimized, achieving a high detection efficiency of sub-2 nm aerosols at a high effective aerosol flow rate (0.6-1 L/min). Parameters governing the optimal performance of aerosol size spectrometers were proposed to quantify the uncertainty in sub-3 nm aerosol measurements. Accordingly, the uncertainties of the new aerosol size spectrometer was reduced to $\sim 20\%$ that of the first prototype. Deploying this new size spectrometer in typical polluted urban atmospheric environments, we observed frequent and intensive new particle formation events. The new particle formation rate of 1.5 nm particles in urban Beijing was found to be magnitudes higher than those reported in relatively clean atmospheric environments. The scavenging of newly formed particles due to coagulation contribute majorly to the formation rate of new particles. Furthermore, coagulation scavenging was often found to be the governing factor for new particle formation events in the polluted atmospheric environment in urban Beijing.

DMA hyphenated with sp ICP-MS for characterizing atmospheric aerosols

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National Central University

Ta-Chih Hsiao, National Taiwan University

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Abstract:

Physical properties, such as particle size, as well as chemical composition, including water soluble inorganic ions, trace metals and carbon contents, are equally important for characterizing atmospheric aerosols. However, most of available chemical analysis techniques are offline methods and not able to provide size-resolved information with high temporal resolution. In this study, we aimed to propose a hyphenated system combining size separation, particle counting, and elemental analysis. A single particle Inductively Coupled Plasma Mass Spectrometry (sp ICP-MS) is thus integrated with a Differential Mobility Analyzer (DMA) for investigating the trace metals of airborne aerosols under different size ranges. The ambient aerosols were firstly classified by a DMA based on selected electric mobility size, and a condensation particle counter (CPC) and sp ICP-MS are then employed as downstream detectors in parallel to provide information about corresponding particle number concentration and elemental composition, respectively. In addition to perform particle size screening, DMA also served as a gas exchange chamber to replace the carrier gas with argon. The gas conversion efficiency within DMA is critical and was systematically evaluated here. On the other hand, varying the carrier gas (changing to argon) in the DMA could also influence the performance of size classification. Therefore, the sizing accuracy for DMA operating with argon was investigated as well.

Use of a Quantitative Reference Aerosol to Validate the Measurement Accuracy of Near Real Time XRF Based Metals Monitors

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Cooper Environmental

Adam Burton, Cooper Environmental

Brian Edge, Cooper Environmental

Jamie Berg, Cooper Environmental

Troy Pittenger, Cooper Environmental

Abstract:

Recently, X-ray fluorescence (XRF) based instruments that measure elemental concentrations in near real time have become available. These monitors often use commercially available thin film standards for calibration of the XRF portion of the instrument. The standards are typically produced by vapor deposition of an element or compound on a substrate and determining the mass of the deposition gravimetrically. Unfortunately, these standards are not available at environmentally relevant concentrations and are also not available on filter substrates that match those typically used in environmental sampling. Short of comparing these instruments to reference method sampling followed by laboratory analysis there has been no easy way to validate the accuracy of these instruments at concentration levels typically found in the environment.

This paper describes an approach to challenging these monitors with environmentally relevant concentrations using a reference aerosol. The aerosol is generated by nebulizing a solution of known concentration, at a measured rate, into a measured volume of air, resulting in an aerosol of a known concentration. A reference aerosol generated in this way was used to challenge an XRF based near real time metals monitor installed on the fence line of an industrial facility as part of a legal settlement with the state of Texas. The monitor reported concentrations for arsenic (As), cobalt (Co), nickel (Ni), molybdenum (Mo) and vanadium (V) and was challenged at three concentration levels for each element. The concentration ranges were chosen to include the State of Texas' Air Monitoring Comparison Value (AMCV) – or the value considered by the state to be a safe level of exposure. The monitor's reported concentration was plotted against the reference aerosol concentration and a least squares regression was performed. Slopes for the comparison varied from a high of 1.11 for vanadium to a low of 0.86 for arsenic with correlation coefficients greater than 0.9 in all cases. Additionally, a reference aerosol has been used to evaluate the accuracy of a XRF based monitor for stack emissions. In this case, the stack monitor was challenged an aerosol consisting of arsenic (As) and lead (Pb) over a concentration range that includes the emission limit. Slopes for this comparison were nearly 1.0.

The reference aerosol may also have applications to checking the accuracy of other types of instruments including PM monitors, and other elemental measurement methods.

Continuous Scanning of the Aerodynamic Aerosol Classifier

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Cambustion

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Jason Olfert, University of Alberta

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Abstract:

The Aerodynamic Aerosol Classifier (AAC, Tavakoli and Olfert, 2013) uses a controlled centrifugal force and clean sheath flow to classify aerosol particles by their mass to drag ratio, which is directly related to their aerodynamic diameter. This operating principle is similar to the Differential Mobility Analyzer (DMA), but classifies by aerodynamic size as opposed to mobility size.

DMA's were first developed into size-spectrometers by step-scanning the deflection voltage (and hence the size), which was known as the Differential Mobility Particle Sizer (DMPS). Following a similar methodology, Johnson et al. (2018) devised and validated an inversion algorithm to measure the aerodynamic size spectrum by stepping the AAC's rotational speed, waiting for the classified particle concentration to stabilize, and measuring this concentration with a Condensation Particle Counter (CPC). This inversion is now incorporated into the commercially available AAC. However, depending on the desired size range and resolution, such step-scans can take a significant time.

This issue also occurred using the DMPS and was overcome by continuously ramping the DMA's voltage, while recording the classified particle concentration. By applying an inversion algorithm to account for the changing voltage, a size spectrum was obtained significantly faster. This arrangement became the basis of the now commercialized Scanning Mobility Particle Sizer (SMPS, Wang and Flagan, 1990).

This current study demonstrates that an equivalent scheme can also be applied to the AAC. By continuously changing the AAC rotational speed and recording the classified particle concentration with a CPC downstream, a high resolution aerodynamic size spectrum can be measured in just a few minutes.

To simplify the scanning inversion considerations, the AAC classifier speed ramp needs to ensure that the change in the centrifugal field acting on a particle over its classifier residence time is independent of its inlet time. This condition is satisfied by a ramp in which the square of the angular velocity is an exponential function of time.

The devised scanning data inversion provides the corresponding aerodynamic diameter for each particle concentration measurement as a function of the elapsed time from the scan's initial speed, the dimensions and flows of the classifier, the CPC counting period, and the transit delay time in the

pipework to the CPC. Unlike the SMPS inversion, no charge correction is needed within the scanning AAC inversion.

This exponential speed ramp and inversion algorithm have been programmed into an AAC. Validation scans have been taken of nebulized Polystyrene Latex (PSL) spheres, showing good agreement with the size standards. In addition, comparisons with AAC step-scans of various aerosols have been made, again showing excellent agreement.

Using an X-ray Source for Bipolar Particle Charging in the Neutral cluster and Air Ion Spectrometer

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Sander Mirme, University of Tartu / Airel Ltd.

Abstract:

The Neutral cluster and Air Ion Spectrometer (NAIS) is widely used for studying atmospheric new particle formation. The instrument can measure the size distribution of naturally charged particles (ions) in the size range from from 0.8 nm to 40 nm and all particles (including both charged and uncharged) from 2.5 nm to 40 nm. Uncharged particles are detected by passing the aerosol sample through a unipolar corona charger. This limits the size range of the instrument as the charger ion sizes overlap with the sample aerosol below 2.5 nm size.

We investigated the possibility of extending the 2 nm lower limit of the neutral particle measurement range of the NAIS by using a soft x-ray source as a bipolar charger.

A Newton Scientific M47 x-ray source was added to the inlet tube of the NAIS and integrated into the data acquisition system of the instrument allowing it to be switched on or off and have its working parameters adjusted by the measurement software. The bipolar charging could be used simply as another operating mode of the instrument in addition to the usual operating modes for measuring ions without charging or all particles with unipolar charging.

The bipolar charging probability function of the charger was found based on the theory by Fuchs. The parameters of the function were measured directly or estimated using calibration experiments. The average electrical mobility was found to be $1.51 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$ for negative charger ions and $1.21 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$ for positive charger ions. The charging probability function was integrated into the instrument matrix of the NAIS. The bipolar charging based NAIS measurements of monodisperse calibration aerosol were fitted against conventional unipolar charging based NAIS measurements as well as an aerosol electrometer and a TSI CPC.

Ambient air measurements were conducted over a period of 11 days. The measurement size range of the instrument was divided into 11 fractions. The average ratio between concentrations measured using unipolar and bipolar charging in these fractions was 0.96 (std. deviation 0.10) for negatively charged particles and 1.02 (std. deviation 0.12) for positively charged particles.

The lowest detectable particle size for the bipolar charger was found to be 2.5 nm. The signal to noise ratio was too low below that size to detect particles at the concentrations provided by our calibration system.

We showed that the NAIS can work well with a bipolar charger and produce reliable results. However the lower size limit for uncharged particles could not be extended further than previously with the conventional unipolar charger. The results were promising but additional research and improvements to the calibration aerosol system are required to determine the actual size limit that is possible with x-ray based charging.

Numerical modeling to investigate the performance of high flow DMAs to classify sub-2 nm particles

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Shuiqing Li, Tsinghua University

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Abstract:

As conventional Differential Mobility Analyzers (DMA) such as nano DMA (TSI 3085) do not have high resolution for classifying sub-2 nm particles¹, a half mini DMA was designed and fabricated to overcome these limitations². In this presentation, a numerical computation is carried out to study the performance of a half mini DMA (short bullet type). Because the sheath flow rate used in a half mini DMA is high, an analysis is first performed to determine the flow compressibility under different conditions³. Second, the governing equations of sheath flow, electric field and aerosol transportation are developed and solved by COMSOL 5.3. The results show that both the height of the transfer function and resolution (R) of the half mini DMA are better than those lower flow systems in the sub-2 nm particle size range. The simulated transfer function of half mini DMA is compared with theoretical models. Additional, in order to elucidate the particle loss, a Brownian Dynamics simulation is used to model the particle trajectories in the inlet and outlet part of the half mini DMA.

[1] Wang, Y., J. Fang, M. Attoui, T. S. Chadha, W.-N. Wang, and P. Biswas. 2014. Application of half mini dma for Sub 2 nm particle size distribution measurement in an electrospray and a flame aerosol reactor. *J. Aerosol Sci.* 71:52–64.

[2] de la Mora, J. F., and J. Kozlowski. 2013. Hand-held differential mobility analyzers of high resolution for 1–30 nm particles: Design and fabrication considerations. *J. Aerosol Sci.* 57:45–53.

[3] Zhang, H., Sharma, G., Wang, Y., Li, S., and P. Biswas. 2018. Numerical modeling of the performance of high flow DMAs to classify sub-2 nm particles. *Aerosol Sci. Technol.* in press. doi: 10.1080/02786826.2018.1549358.

Semi-dry Electrostatic Precipitator (SDEP) Based Systems for Real-time Monitoring of PM_{2.5} Precursor Gases, Inorganic Ions and Metals

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Abstract:

In this study, the real-time PM_{2.5} chemical composition monitoring system was developed based on the semi-dry electrostatic precipitator (SDEP) which has high PM_{2.5} collection efficiency, ions recovery efficiency and low ozone release (83±14 ppb). The SDEP was integrated with a parallel plate wet denuder (PPWD) and IC as a PPWD-SDEP-IC system for hourly monitoring of PM_{2.5} inorganic ions and precursor gases, or with an auto vial collector (AVC) as a SDEP-AVC system for storing hourly PM_{2.5} samples which were then analyzed for determining the metal composition by ICP-MS (SDEP-AVC/ICP-MS). In the field tests, inorganic ions and precursor gases monitored by PPWD-SDEP-IC system were compared to those by PILS-IC system and a manual denuder which is used as the reference. Additionally, the daily PM_{2.5} metal composition of SDEP-AVC/ICP-MS was compared to that collected by Dichot and analyzed by ICP-MS (Dichot/ICP-MS) as the reference which was first tested with the commercialized real-time metal detector Xact625i to evaluate the accuracy.

The result of PPWD-SDEP-IC shows that the daily concentrations of precursor gases (NH₃, HONO, HNO₃ and SO₂) and inorganic ions (Na⁺, NH₄⁺, K⁺, Cl⁻, NO₃⁻ and SO₄²⁻) are consistent with those of the reference manual denuder, which have the slopes of 0.92-1.06 and R² values of 0.964-0.992 with linear regression. For hourly comparison, the concentration measured by PILS-IC are 16.5% lower for NH₄⁺ and 8.7% higher for NO₃⁻ as compared to PPWD-SDEP-IC system, which is caused by the drawback of steam condensation method. For metal composition, the result of Dichot/ICP-MS vs. Xact625i shows that the concentrations of 13 elements have good agreement, while the result of Dichot/ICP-MS vs. SDEP-AVC/ICP-MS shows that concentrations of 19 elements are comparable. This is because that the detection limits of metal concentration analyzed by ICP-MS are mostly lower than those by the X-ray Fluorescence method which is employed in Xact625i. Moreover, the result of Dichot/ICP-MS vs. SDEP-AVC/ICP-MS also reveals that the concentrations of some metals such as As, Sb, Ge, Sn, Y and La of

SDEP-AVC/ICP-MS are almost 0 ng/m³, which are much lower than those of the Dichot/ICP-MS. It is due to the low background concentration of DI water which is used to extract the PM_{2.5} sample collected in the SDEP. To be noticed, because the PM_{2.5} sample collected by the SDEP is extracted by DI water into the liquid phase, no microwave digestion is needed, and, consequently, most metallic limits of detection (LoD) of SDEP-AVC/ICP-MS are lower than those of Dichot/ICP-MS in which the filter is used to collect PM_{2.5}. As a result, the SDEP-based system has the high accuracy and great potential for chemical composition analysis in real-time. The inclined high background concentration of NO₃⁻ in the PPWD-SDEP-IC (0.63 µg/m³) and the dissolution of some metallic species in SDEP-AVC systems remain to be resolved by reducing the RH value and surface coating, respectively, in our future work.

Keywords: PPWD-SDEP-IC, SDEP-AVC, ICP-MS, chemical composition, inorganic ion, precursor gas, metal

Impact of Tropospheric Downwash on Pearl River Delta Air Quality during Southeast Biomass Burning

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Abstract:

Biomass burning is recognized as an important source of carbon monoxide, ozone and particulate matter, which not only affects local air quality, but also air quality at distant places. This study investigated the impacts of biomass burning emissions from Southeast Asia (SEA) and its contribution to local air pollution in Hong Kong. Biomass burning events in the spring from 2012 to 2014 were first identified by using GFED (Global Fire Emission Data) fire emissions with HYSPLIT (Hybrid Single Particle Lagrangian-Integrated Trajectory) backward trajectory dispersion modeling analysis. Cross comparison between event and non-event days was performed using local air quality observation (e.g., nss-K+, PM_{2.5}/PM₁₀ ratio) to ensure the present of biomass burning signatures. After that, regional air quality model, WRF-CMAQ (Weather Research and Forecasting (WRF) and Community Multi-Scale Air) with 4 nested domains (i.e., 27, 9, 3 and 1 km) and two scenarios (with or without biomass burning emissions) were applied to evaluate the contribution of biomass burning during the downwash events on local air pollution. The results provide us a better understanding on how long-range transport of SEA biomass burning affects local air quality in South China.

Secondary organic aerosol enhanced by increasing atmospheric oxidizing capacity in Beijing-Tianjin-Hebei (BTH), China

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Abstract:

The implementation of the Air Pollution Prevention and Control Action Plan in China since 2013 has profoundly altered the ambient pollutants in the Beijing-Tianjin-Hebei region (BTH). Here we show observations of dramatically increased O₃ concentration (about 30%) and a remarkable increase in the ratio of aerosol organic carbon (OC) to elemental carbon (EC) in BTH during the autumn from 2013 to 2015, revealing an increase in atmospheric oxidizing capacity (AOC) and an enhancement of secondary organic aerosol (SOA) formation. To explore the impacts of increasing AOC on the SOA formation, a severe air pollution episode from 3 to 8 October 2015 with high O₃ and PM_{2.5} concentrations is simulated using the WRF-Chem model. The model performs reasonably well in simulating the spatial distributions of PM_{2.5} and O₃ concentrations over BTH and the temporal variations of PM_{2.5}, O₃, NO₂, OC, and EC concentrations in Beijing compared to measurements. Sensitivity studies show that the change in AOC substantially influences the SOA formation in BTH. A case characterized by a 31% O₃ decrease (or 36% OH decrease) reduces the SOA level by about 30% and the SOA fraction in total organic aerosol by 17% (from 0.52 to 0.43). Spatially, the SOA decrease caused by reduced AOC is ubiquitous in BTH, but the spatial relationship between SOA concentration and AOC is complicated. Studies on SOA formation pathways further show that, in the reduced AOC situation, the SOA generated by the pathway of semi-volatile POA oxidation and partitioning significantly decreases, followed by the pathways involving anthropogenic and biogenic volatile organic compounds; while the SOA decrease in the irreversible uptake of glyoxal and methylglyoxal on aerosol surfaces is negligible.

Consistent modeling approach for multispecies aerosol formation using sectional and moment methods in AeroSolved

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Abstract:

Computational modeling of evolving liquid aerosol mixtures remains a challenge due to accounting for many coupled processes related to aerosol physics and chemistry, computing costs, and complex approaches for treatment of phenomenological models at various levels of physical assumptions. We have developed a Computational Fluid Dynamics code “AeroSolved” for simulation of the formation, transport, evolution and deposition of multispecies aerosol mixtures. The aerosol is described within an Eulerian framework with the aerosol size distribution represented by either a sectional or a two-moment method, in the two-fluid representation. The code is based on the OpenFOAM software package.

The two-fluid representation implies separate treatment of mass, momentum, and energy for each phase (gas-liquid) and each species. Assuming a dilute aerosol mixture with limited impact on the total momentum and energy, we reduce the computational complexity of such an approach by solving the transport equations for each species and phase while treating the energy and momentum only for the total mixture as a whole. A drift flux approach is used to transport each species relative to the mixture by computing relative velocities and diffusion terms. The two-moment method assumes a log-normal shape of the size distribution with a fixed Geometric Standard Deviation (GSD), parametrizing the particle number density with the average size of particles in a computational cell. On the contrary, the sectional method resolves the particle size distribution without making a priori assumptions on the shape of the distribution. In this work we concentrate on the development of the consistent modeling approach for aerosol formation including nucleation, condensation and evaporation processes in the multispecies context.

For the modeling of the nucleation process we use modified classical nucleation theory, extended for the multispecies mixtures. This requires computation of the nucleation critical cluster composition, nucleation rate and condensation rate for each species. The species-specific condensation rate function introduces a modification of the standard single-species condensation rate to account for the Stefan flow. The presence of this modification allows changing the sign of the condensation rate function under thermodynamic conditions and implies that a supersaturated vapor can evaporate or that an

undersaturated vapor can condense. We show that this modified formula has the advantage of predicting a critical cluster composition which is consistent with the condensation model, and therefore does not immediately evaporate. We develop and apply such consistent approach to both two-moment and sectional methods for the treatment of the particle size distribution.

The models are tested and validated against available literature and cases (e.g., aerosol formation in a Laminar Flow Diffusion Chamber). The developed analytical treatment of the condensational growth term is shown to have a superior performance over an explicit time integration. By comparing the two methods, we conclude that the choice of the GSD value plays an important role in the modeling of aerosol formation using the two-moment method. On the contrary, the two-moment method is computationally less demanding than the sectional method. We will present numerical simulation results for varying thermodynamical conditions and parametric studies concerning developed models applications.

Aerosol physical and chemical properties and their impact on radiation over East Asia

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Abstract:

Aerosol pollution have become a severe problem over East Asia, especially over those densely-populated and industrialized regions, for example, China. Aerosol particles increase dramatically during a heavy haze event, which probably influence the radiation and energy budget given their complex chemical component. For example, sulfate, nitrate and sea salt are mostly scattering particles while black carbon and mineral dust have more strong absorption. Physical and chemical properties of aerosol particles, including concentration, size distribution, chemical component, and mixing state, etc. could change significantly depending on the processes, and thus influence the radiation and energy budget. In this study, we explore the impact of these properties on radiation at top of atmosphere (TOA), surface, and heating rate over East Asia, by employing a nested version of global chemical transport model (GEOS-Chem) coupled with a size-resolved aerosol module (APM), i.e. GEOS-Chem/APM. The detailed quantitative analysis and discussion will be presented.

An assimilation method of lidar data based on CRTM and WRF-Chem model and its application to PM_{2.5} forecasting over the Beijing-Tianjin-Hebei Region

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Abstract:

A three-dimensional variational (3DVAR) assimilation method of lidar data is developed based on the Community Radiative Transfer Model (CRTM) and Weather Research and Forecasting model coupled to Chemistry (WRF-Chem). The Vertical layered 3DVAR data assimilation system using the lidar backscatter coefficients observation data is established for the MOSIAIC aerosol mechanism in the WRF-Chem model. Hourly lidar data at four stations in Beijing from 12:00 to 18:00 UTC on March 13, 2018 are assimilated into the initial fields simulated by the WRF-Chem model and used to forecast 24h PM_{2.5} concentration from 19:00 UTC on Mar. 13 to 18 UTC on Mar 14, 2018 over the Beijing-Tianjin-Hebei (BTH) Region which PM_{2.5} concentration is very high in this period. Results show that spatial distribution of PM_{2.5} concentration on the surface and high layer are obviously improved after lidar data assimilation. Namely the modelled PM_{2.5} concentration without assimilation is very lower than the observations, but simulated values with assimilation increase significantly in Beijing and its surrounding area and increments on the surface and 925hpa are respectively 20 ~ 80 $\mu\text{g}\cdot\text{m}^{-3}$ and 20 ~ 140 $\mu\text{g}\cdot\text{m}^{-3}$. Especially the vertical distribution of PM_{2.5} concentration in Beijing is improved remarkably and increased layers of PM_{2.5} are located from surface to 1200m height. Among five species of aerosol, increments of NO₃⁺ and SOA are the most significant, SO₄²⁻ takes second place, those of OC and EC are the smallest. This is consistent with other observed results which showed that NO₃⁺ and SOA will increase obviously during the heavy haze episode over the BTH Region. The above results indirectly show that PM_{2.5} simulated concentrations by the WRF-Chem model are underestimated over the BTH area. Averaged forecasted PM_{2.5} concentration during the 6th ~ 25th hour after assimilation on 47 stations over the BTH region are very closed to observations compared with the forecasting results without assimilation. Correlation coefficients between forecasted PM_{2.5} concentration and observed

values for 47 stations are higher by averaged 0.1 than those without assimilation during the 6th ~ 25th hour. RMSE of averaged forecasted PM_{2.5} concentration with assimilation at 47 stations is smaller by averaged 20 $\mu\text{g}\cdot\text{m}^{-3}$ than those without assimilation. But forecasting errors will increase from 26th hours after assimilation because of limited lidar observed stations.

Poster Session

Display Date & Time: 09:15, 28 May 2019 (Tuesday) – 17:30, 29 May 2019 (Wednesday)

Authors in Attendance Date & Time: 15:30-17:30, 29 May 2019 (Wednesday)

Poster Venue: Purple Zone, 4/F, University-Concourse, Yeung Kin Man Academic Building, City University of Hong Kong

Session Chair: Theodora Nah, City University of Hong Kong

Special Symposium: Atmospheric aging		
Speaker	Title	Poster number
Anthony Wexler, UC Davis	Near-Roadway Alzheimer's Disease	P1-001
Jiawen Xie, The Hong Kong Polytechnic University	Source-specific health risks of PM _{2.5} -associated trace metals: A comparative analysis of the Yangtze River Delta and Pearl River Delta regions in China	P1-002

Special Symposium: Aerosol mass spectrometry		
Speaker	Title	Poster number
Lu Lei, IAP	Investigation of aerosol chemical composition and sources in the vicinity of steel plants	P1-003
Liming Cao, Peking University Shenzhen Graduate School	Characterization of high resolution mass spectra of Primary Organic Aerosol	P1-004
Weiwei Hu, Chinese Academy of Sciences	The volatility of source resolved ambient organic aerosols (OA) in urban area of Guangzhou	P1-005
Qingqing Wang, Chinese Academy of Sciences	Temporal characteristics and vertical distribution of atmospheric ammonia and ammonium in winter in Beijing	P1-006
Jing Duan, Chinese Academy of Sciences	Seasonal variation of urban aerosol in Beijing: composition, sources and secondary formation	P1-007
Yao Xiao, Peking University	Origin of secondary organic aerosols: Insights to aqueous-phase SOA formation in Beijing during wintertime	P1-008
Yang Chen, Chinese Academy of Sciences	Characterization of non-refractory PM _{2.5} in Chengdu, Southwestern China using a Time-of-Flight Aerosol Chemical Speciation Monitor (ToF-ACSM)	P1-009
Yan Zheng, Peking University	Formation and Aging of Secondary Organic Aerosol from Aromatic Compounds	P1-010
Shan Huang, Jinan University	Characterization of urban aerosol particles using Soot Particle-Aerosol Mass Spectrometer (SP-AMS) during GBA2018	P1-011

Special Symposium: Sulfur aerosol chemistry		
Speaker	Title	Poster number
Kai Chung Kwong, The Chinese University of Hong Kong, Hong Kong	Formation of Inorganic Sulfate from Organosulfur Compounds through the Heterogeneous OH Oxidation	P1-012
Shuai Shuai Ma, Beijing Institute of Technology	Dynamic deliquescence process of aerosols by the upward RH pulse mode	P1-013
Jianzhen Yu, Hong Kong University of Science & Technology	Abundance of Organosulfur in Atmospheric Humic-like Substance	P1-014

Aerosol chemistry		
Speaker	Title	Poster number
Liyuan Zhou, City University of Hong Kong	Characterization of primary organic aerosols and secondary organic aerosols from heated fatty oils	P1-015

Min Kyung Kang, Ewha Womans University	Urban and Rural Difference of SOA Tracer Characteristics in Korea	P1-016
Rongshuang Xu, The Chinese University of Hong Kong	Chemical Transformation of Erythritol Aerosols through Heterogeneous OH Oxidation: Kinetics, Chemistry and Reaction Products	P1-017
Mitsuo Dairiki, Waseda University	Observation of Cloud Water Chemistry in the Free Troposphere at the summit of Mt.Fuji	P1-018
Kojiro Shimada, Waseda University	Degradation of PAHs during long range transport simultaneously measured at Tuoji island, China and Cape Hedo, Japan	P1-019
Duangduean Thepnuan, Chiang Mai University	Source indicators of biomass burning associated with water soluble ions and anhydrosugars during smoke haze period in Upper Northern Thailand	P1-020
Olli Sippula, University of Eastern Finland	EMISSION CONTROL MEASURES AFFECTED PM2.5 CONCENTRATION AND COMPOSITION DURING THE 2014 YOUTH OLYMPIC GAMES IN NANJING	P1-021
Ryoko Fujioka, Kanazawa University	Co-spray drying of silver nanocolloids and target molecules for surface-enhanced Raman spectroscopy	P1-022
Yaowatat Boongla, Kanazawa University	Analysis of polycyclic aromatic hydrocarbons and their nitro-derivatives by using HPLC-fluorescence developed method	P1-023
Tomoaki Ichige, Tokyo University of Science	Individual Particle Analysis of Aerosol Particles Collected at Mt. Fuji in the Summer of 2018	P1-024
Soyoung Jung, Seoul National University	Characteristics of organic compounds in PM2.5 aerosols during high concentration events measured in Seoul, Korea	P1-025
Zhiheng Wang, China University of Petroleum	Quantification and Molecular Characterization of Atmospheric Brown Carbon by LC-HRMS	P1-026
Zhang Lingzhi	Identification of Tautomer of Phthalic Anhydride in Atmospheric Aerosols by TIMS TOF MS	P1-027
Hung-Li Wang, National Tsing Hua University	A Facile Quantification of Hyaluronic Acid and its Crosslinking Using Gas-Phase Electrophoresis	P1-028
Shibao Wang, Nankai University	Temporal patterns and source apportionment of PM2.5-bound Polycyclic aromatic hydrocarbons: a case study of Anshan, a typical steel industry city in northeast China	P1-029
Katsutomu Saito, Keio University	Chemical speciation of chromium in atmospheric particulate matter collected with filter and cyclone by XAFS method	P1-030
Seungshik Park, Chonnam National University	In-depth analysis of high PM2.5 pollution during March 2018 in Gwangju, Korea	P1-031
Cheng Wu, Jinan University	Characteristics of carbonaceous aerosols in North China Plain during Winter haze	P1-032
Worrador Phairuang, Prince of Songkla University	Characteristic of particulate matter down to PM0.1 in Southern Thailand	P1-033
Tian Zhang, Xi'an Jiaotong University	Investigation of optical properties and chemical characterization of humic-like substances (HULIS) in PM2.5 over Xi'an, China	P1-034
L.-W. Antony Chen, University of Nevada	An empirical approach towards quantifying black and brown carbon contents from multi-wavelength thermal/optical analysis	P1-035
Lei Zhang, Nankai University	Characteristics and Sources apportionment of Carbon Components in PM2.5 During Autumn and Winter in Panjin City	P1-036
Bok-Jin Lee, Chonnam National University	Investigation of absorption properties of aerosol particles and mass absorption cross section of black carbon at an urban site	P1-037
Shuya Hu, Peking University	Light absorption of brown carbon and its relationship with aerosol chemical compositions in northern China	P1-038
Chaoying Wang, Chinese Academy of Sciences	An Intercomparison of aerosol absorption coefficient of several instruments in Beijing city	P1-039
Ki Ae Kim, Ewha Womans University	Characteristics of Carbonaceous aerosols in PM2.5 based on Long-term observation at a GAW regional station in Korea	P1-040
Jeonghoon Lee, Korea University of Technology and Education	Derivation of A Correlation Regarding Light Absorbing Carbon based on Thermal Elemental Carbon (EC) and Equivalent Black Carbon (eBC)	P1-041
Shantanu Kumar Pani, National Central University	Characteristics and source apportionment of ambient black carbon over an urban atmosphere in northern Southeast Asia	P1-042
Mikinori Kuwata, Nanyang Technological University	Determining Polarity Distribution of Atmospheric Water-Soluble Organic Matter by the 1-Octanol-Water Extraction Method	P1-043
Yiqiu Ma, Hong Kong Baptist University	Chemical characteristic, source apportionment and health implications of humic-like substance (HULISWS) in fine particulate matter (PM2.5) in Hong Kong	P1-044
Ryota Kuniyama, Kanazawa University	Application of SERS on the Chemical Analysis of Nanometer Sized Aerosol Particles	P1-045
Ryota Kuniyama, Kanazawa University	Application of Electro Spray Surface-Enhanced Raman Scattering (ES-SERS) Technique for the Characterization of Core-Shell Particles	P1-046
Long Chen, Chinese Academy of Sciences	Effect of Oligomerization Reactions of Criegee Intermediate with Organic Acid/Peroxy Radical on Secondary Organic Aerosol Formation from Isoprene Ozonolysis	P1-047

Xiongfeng Huang, Xiamen University	Simultaneous, Sensitive and Simple Determination of Amino Acids and Amines in Continental and Marine Aerosols	P1-048
Chiemiwo Godday Osuagwu, Queensland University of Technology	The role of Fuel's Oxygen Content on Unregulated Emissions from Biodiesel Blends	P1-049
Branka Miljevic, Queensland University of Technology	Observation of VOC emissions from diesel exhaust using H ₃ O ⁺ Chemical Ionisation Mass Spectrometer (CIMS)	P1-050

Bioaerosol		
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Near-Roadway Alzheimer's Disease

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Abstract:

Recent epidemiological studies have linked traffic-related air pollution (TRAP) to increased risk of Alzheimer's disease (AD). In addition, in vivo and in vitro studies have shown that individual components of TRAP can alter neuroinflammation, increase neurotransmitter levels, and increase neurogenesis. However, TRAP exposures are challenging to reproduce in laboratory settings, and the mechanisms by which TRAP leads to Alzheimer's-related cognitive deficits remain unclear. To address these issues, we exposed male and female Sprague-Dawley rats to real-time TRAP, using an exposure facility that samples air directly from a highway tunnel in the Bay Area of California used by both light- and heavy-duty vehicles. TRAP and filtered air (FA) samples were collected for 24 hours once every third day, and a subset of these were analyzed for particulate matter mass, organic and elemental carbon composition, and elemental composition. Gas phase samples were collected monthly on sorbents and analyzed for molecular organics. The goal of this project is to test the hypotheses that exposure to TRAP triggers inflammatory responses in the brain that initiate, accelerate or exacerbate progressive AD pathology and cognitive dysfunction, and that the response to TRAP varies depending upon sex, age, and expression of AD susceptibility genes. To test this hypothesis, we quantified behavioral changes, cytokines in the periphery and brain, neuroinflammation, AD-like pathology and cognitive behavior in rats genetically predisposed to AD and their wildtype littermates exposed to ambient TRAP from the tunnel beginning at 28 days postnatal. Outcomes in these animals are compared to responses in age-, sex- and genotype-matched controls exposed to clean filtered air (FA). This work was supported by the NIEHS (grants R21 ES025570 and P30 ES023513), NIA (grant P30AG010129), NICHD (grant U54 HD079125) and NIMH (T32 MH112507).

Source-specific health risks of PM_{2.5}-associated trace metals: A comparative analysis of the Yangtze River Delta and Pearl River Delta regions in China

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Abstract:

PM_{2.5} pollution has become one of the most severe environmental problems in China in recent decades and caused a range of health issues. For health-oriented air pollution control, it is vital to rank the contribution of different emission sources according to the health risks posed by hazardous components in PM_{2.5}. With a focus on trace metals, an important contributor to PM_{2.5} health effects, this study aimed to apportion the total health risks posed by metals from different source categories in a quantitative manner.

PM_{2.5} samples were collected simultaneously from spring 2016 – spring 2017 in two densely populated regions, the Yangtze River Delta (YRD; industrial-urban-rural) in eastern China, and the Pearl River Delta (PRD; urban-suburban-semirural) in southern China. Chemical speciation of PM_{2.5} samples included organic carbon, elemental carbon, water-soluble ions, and trace metals for source apportionment of trace metals using the Positive Matrix Factorization (PMF) model. The pulmonary bioavailability of metals was assessed by the simulated lung fluid (Gamble's solution). The carcinogenic and non-carcinogenic risks posed by these metals were estimated based on their respective bioavailable concentrations and reference doses. We aggregated element-specific contribution of each source category for all the trace metals, and resolved the quantitative contribution of each source category to the health risks posed by these PM_{2.5}-associated metals.

The concentrations of PM_{2.5} were higher in the YRD than in the PRD (~20% on average across the year). Chemical compositions of PM_{2.5} varied between the two regions, with the notable differences in higher contribution of secondary inorganic aerosols and lower contribution of organic matter to PM_{2.5} in the YRD than in the PRD. Within each region, the particulate trace element profiles reflected the land-use gradient. The highest concentrations of enriched metals as anthropogenic signals were detected at the YRD industrial site (Pb and Cu) and at the PRD semi-rural site subject to urban and industrial expansion (e.g., As, Cd, and Zn). The estimated pulmonary bioavailability of trace elements was high for As, Mn and

V, moderate for Co, Ni, Cu and Cd, but low for Fe, Zn, and Pb. The resulting carcinogenic and non-carcinogenic health risks posed by these elements were significantly higher in the YRD than in the PRD (~1.4 times). Arsenic was the dominant contributor (71-89%) to the total excessive cancer risks of these elements in both regions. Vehicular emission and fugitive dust was the dominant contributing source of metal-posed cancer risks in both regions (66% in the PRD and 60% in the YRD), followed by coal combustion and incineration in the YRD (21%), and by shipping emissions and sea salts in the PRD (20%). For the non-carcinogenic risks, the relative contribution of each source was similar, except for industrial emission as the second largest contributor in the YRD.

Our comprehensive analysis of two key regions in China provided region-specific insights into the health risks of PM_{2.5}-associated trace metals in linkage to their emission sources. The novel understanding represents a critical contribution to the formulation of risk mitigation and pollution control strategies adaptive to regional scenarios.

Investigation of aerosol chemical composition and sources in the vicinity of steel plants

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Abstract:

Atmospheric aerosols have great impacts on the visibility, climate, and human health. Exposure to higher concentrations of aerosol particle near large point sources should be more concerned. Here we have a comprehensive characterization of aerosol chemical composition and sources near two steel plants in a coastal city Rizhao, Shandong using a PM_{2.5} Time-of Flight Aerosol Chemical Speciation Monitor (ToF-ACSM), a Single Particle Aerosol Mass Spectrometer (SP-AMS), and various collocated instruments from 1st to 30th, September, 2018. The average mass concentration of PM_{2.5} was 26.4 (± 22.9) $\mu\text{g}/\text{m}^3$ for the entire study, which was mainly composed of organics (34.8%), sulfate (24.8%) and nitrate (13.9%). Positive matrix factorization of ToF-ACSM organic aerosol (OA) identified one primary and two secondary OA (SOA) factors with SOA being the major fraction (86%). During this campaign, we observed clear impacts of emissions of steel plants on downwind sites as indicated by high concentrations of Fe-containing and Pb-containing particles. The average mass concentration of PM_{2.5} during the industrial plume was more than 4 times higher than those during normal periods, and aerosol composition was dominated by ammonium sulfate/ammonium bisulfate. In addition, the influences of sea and land breeze on aerosol composition and diurnal variations were also discussed.

Characterization of high resolution mass spectra of Primary Organic Aerosol

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Abstract:

Organic aerosols (OA) contribute a significant fraction of submicron aerosols in the atmosphere. Primary OA (POA) is emitted directly from sources and is mostly comparable from different data sets. Factor analysis of mass spectra (MS) measured by aerosol mass spectrometer (AMS) has been proved to be a very useful way to interpret and attribute the sources of the ambient OA. In order to further understand the MS signatures of different POA and help the interpretation of factor analysis of ambient OA, direct measurement of the MS profiles of POA by the AMS is needed. The emissions of four dominant POA, including three types of Hydrocarbon-like OA (HOA), four types of cooking OA (COA), six types of biomass burning OA (BBOA) and three types of coal combustion OA (CCOA) were measured and analyzed by the High resolution time-of-flight AMS in the Laboratory of Biomass Burning Simulation at Peking University Shenzhen Graduate School in this study. The high resolution MS (HR-MS) of OA could help figure the difference and tracers of different sources of OA more clearly than the unit mass resolution (UMR-MS). The average O/C ratio of HOA, COA, CCOA and BBOA is 0.06, 0.14, 0.19 and 0.29, respectively. The MS signatures of HOA, COA, BBOA and CCOA are also discussed in the study. The MS profiles of HOA obtained under different conditions showed similar signatures and also comparable with different data sets in the literature, and the conclusion is also suitable for COA, CCOA and BBOA. Compared with the results by the factor analysis of ambient OA, the HOA, COA, CCOA and BBOA obtained from the simulation system are much more purified and not contaminated by other sources, which could be used as important reference information for factor analysis of ambient OA. The MS profiles are also applied to ambient data obtained in summer and winter in Shenzhen, China, testified that they can be used properly for source apportionment of ambient OA.

The volatility of source resolved ambient organic aerosols (OA) in urban area of Guangzhou

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Abstract:

Volatility, which determines the gas-particle partitioning of organic species, plays an important role for chemical process and fate of organic aerosols (OA).

To investigate the volatility of ambient OA, we conducted a comprehensive field campaign at an urban site of Guangzhou from Oct to Nov 2018. A thermodenuder (TD), coupled with Aerodyne High-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) and scanning mobility particle sizer (SMPS) was deployed. The TD temperature rose linearly from 25°C to 250°C in one and a half hours and then cooled down to room temperature by fans within 5 minutes. The accuracy of TD temperature and particles losses at different size (20-200 nm) was determined by laboratory experiments. TD and ambient sampling line was switched in every 4 minutes. By comparing mass concentrations from thermal-heated aerosols versus ambient aerosols, mass fraction remaining (MFR) from OA and other main chemical species (e.g., sulfate, nitrate) as a function of TD temperature was explored. Aerosols were found to be acidic at higher TD temperatures due to early NH₄ evaporation, which is consistent with previous literature results. Different OA sources including hydrocarbon-like organic aerosols (HOA) and oxygenated organic aerosols (OOA) were resolved using positive matrix factorization (PMF). Volatilities of different OA sources were estimated with a kinetic model. Consistent with other urban studies, an extreme low volatility ($C^* < 10^{-4} \mu\text{g m}^{-3}$) was found for OOA and higher volatility for HOA ($C^* \sim 10^{-2} \mu\text{g m}^{-3}$) was found.

Temporal characteristics and vertical distribution of atmospheric ammonia and ammonium in winter in Beijing

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Abstract:

Ammonia plays an important role in the formation of secondary inorganic aerosols during haze episodes in China. To understand the temporal characteristics and vertical distributions of ammonia and ammonium in Beijing during winter, we conducted ground-based measurements of gaseous NH₃ and submicron aerosol composition from 16 November 2016 to 22 December 2016 at an urban site in Beijing. Vertical profiles (50 in total) of NH₃ between the ground level and 260 m were also acquired. In this study, the average mixing ratio of NH₃ was 16.5 ± 7.4 ppb, ranging from 3.8 to 36.9 ppb. Gas-to-particle partitioning of NH_x (= NH₃ + NH₄) played a significant role on NH₃ concentration as the molar ratio of NH₃ to NH_x decreased as a function of NH₄ concentration and total submicron mass (PM₁). The NH₃ concentrations increased as a function of PM at lower levels (< 125 μg m⁻³), but remained relatively constant at higher PM and NH₄ levels, indicating an enhanced gas-to-particle conversion of NH₃ during highly polluted conditions. The potential sources of NH_x were found to include biomass burning and fossil fuel combustion. Regional transport could also play an important role on NH₃ concentration during the formation stage of haze episodes due to particle-to-gas conversion. Four different types of vertical profiles (87% of the time) of both NH₃ and bext were also observed which are associated with well-mixed atmosphere, fast accumulation of local emissions, regional transport at high altitudes, and the formation of low urban boundary layer, respectively. However, the vertical profiles of NH₃ typically showed more a homogeneous characteristic than those of bext below 260 m, likely due to gas-to-particle partitioning of NH₃ and the stronger diffusivity of NH₃ gas. Occasionally, the strong effect of gas-to-particle partitioning of NH₃ appeared to cause opposite trends in NH₃ and bext vertical profiles.

Seasonal variation of urban aerosol in Beijing: composition, sources and secondary formation

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Abstract:

Severe haze pollution events with high concentrations of particulate matter (PM) are still frequently observed during all seasons in Beijing, China. Despite numerous studies on haze pollution in Beijing, our knowledge about the composition, source and evolution mechanism of PM is still not complete. We deployed an aerosol chemical speciation monitor (ACSM) for real-time measurement of PM₁ and presented the seasonal variations of chemical composition, sources and atmospheric evolution of PM₁ in Beijing. The average mass concentration of PM₁ varied from late summer to autumn and early winter, with organic aerosol (OA) contributing the major fraction during all three seasons, followed by nitrate or sulfate. Positive matrix factorization (PMF) analysis with multi-linear engine (ME-2) on the organic portion of the ACSM data resolved five OA sources including hydrocarbon-like OA (HOA), cooking OA (COA), coal combustion OA (CCOA), local secondary OA (LSOA) and regional SOA (RSOA). Secondary aerosol species including SIA (sulfate, nitrate and ammonium) and SOA (LSOA and RSOA) dominated PM₁ during all three seasons, and higher contributions of secondary species (SIA and SOA) were also observed in pollution episodes than in clean episodes during all three seasons, further emphasizing the importance of secondary formation process in haze pollution in Beijing.

Origin of secondary organic aerosols: Insights to aqueous-phase SOA formation in Beijing during wintertime

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Abstract:

With significant SO₂ emissions reduction in recent years, nitrate has become a dominant constituent of atmospheric submicron aerosols over North China Plain. As RH increases during haze episodes, the water uptake driven by particulate nitrate may lead to enhancement of aerosol liquid water content (ALWC), thereby, implying the importance of aqueous-phase processing in secondary aerosols formation.

To investigate the formation and evolution of submicron aerosol (PM₁) in Beijing urban areas, a high-resolution time-of-flight aerosol-mass-spectrometer (HR-ToF-AMS) was utilized to measure the chemical composition of non-refractory PM₁ (NR-PM₁) at an urban site in winter (November to December 2017), coupled with multiple state of the art online instruments. NR-PM₁ mass concentrations in winter varied dramatically under different meteorological conditions. The average mass concentration of PM₁ was $29 \pm 35 \mu\text{g}/\text{m}^3$. Organics accounted for 38%, and 27% of NR-PM₁ was nitrate. Source apportionment resulted from the PMF analysis showed that about half of OA contributed by secondary organic aerosols during the field campaign. As examples, two typical pollution episodes were deeply analyzed. The first episode is from November 3 to November 7. The nitrate fraction accounted for about 40%. The second event occurred from December 26 to December 30. Different from the first event, the sulfate is the major contributor of inorganic fraction of PM₁. The PMF analysis showed that the contribution of MO-OA to OA increases substantially as a function of relative humidity or aerosol liquid water content. Higher oxygen-to-carbon ratios of SOA during periods with higher RH were also found, indicating a major role of aqueous-phase processing in changing the oxidation degree of SOA in Beijing.

Characterization of non-refractory PM_{2.5} in Chengdu, Southwestern China using a Time-of-Flight Aerosol Chemical Speciation Monitor (ToF-ACSM)

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Abstract:

Chengdu is the most important and polluted city in Southwestern China, but the characterization, evolution, and source of PM_{2.5} are still poorly understood. A time-of-flight aerosol chemical speciation monitor equipped with a PM_{2.5} aerodynamic lens was deployed in a rural site of Chengdu to investigate the characterization of urban aerosol during wintertime. The temporal trends, diurnal patterns of major chemical components, including organics, sulfate, nitrate, ammonium, and chloride was reported. The effect of relative humidity on the evolution of organics was also investigated. Positive matrix factorization (PMF) was used for source apportionment of organic aerosols (OA). To our best knowledge, it is the first dataset conducting online measurement of non-refractory PM_{2.5} in southwestern China.

Formation and Aging of Secondary Organic Aerosol from Aromatic Compounds

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Yongjie Li, University of Macau

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Abstract:

Oxidation flow reactors have been widely used to study the formation and evolution of secondary organic aerosol (SOA) over time scales ranging from hours to multiple days of equivalent atmospheric exposure. We deployed a Potential Aerosol Mass (PAM) flow reactor in the laboratory to study the formation and oxidative aging of SOA from typical aromatic precursors such as benzene, toluene and naphthalene. NO_x levels in the PAM chamber were controlled by N₂O injection. Gas-phase precursors and oxidation products are detected by using a proton transfer reaction mass spectrometer and a nitrate-ion chemical ionization time-of-flight mass spectrometer. Non-refractory particle components were detected by using a high-performance time-of-flight aerosol mass spectrometer. Data are compared to ambient observations in Beijing. The mass spectra of highly oxygenated molecules (HOMs) produced by the photooxidation of the three types of aromatic precursors cannot resemble the ambient spectra, suggesting that the majority of HOMs may come from other sources in Beijing. Particle-phase organic nitrate contributes greatly to the SOA mass under conditions of high NO_x. The mass fraction of organic nitrate in organic aerosol is highest for toluene SOA and lowest for naphthalene SOA. However, PAM-generated aromatic SOA shows much less N-containing fragments in the spectra compared to urban SOA in Beijing, implying important brown carbon sources other than aromatic oxidation. The elemental ratios of PAM-generated SOA agree well with the previous findings. As the exposure level increases, the atomic oxygen-to-carbon (O/C) ratios of benzene and toluene SOA increase and the hydrogen-to-carbon (H/C) ratios decrease. In contrast, the H/C ratios of SOA generated from naphthalene photooxidation show an opposite trend with aging, suggesting significant fragmentation.

Characterization of urban aerosol particles using Soot Particle-Aerosol Mass Spectrometer (SP- AMS) during GBA2018

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Abstract:

Atmospheric carbon-containing compounds including volatile organic compounds (VOCs), organic aerosols (OA) and black carbon (BC) may contribute significantly to the urban haze events and complex air pollution. In order to explore the formation, transfer, and depletion of carbon-containing compounds, a comprehensive campaign was conducted in the autumn of 2018 in Great Bay Area of South China (i.e., GBA2018 campaign). For the first time, a soot particle aerosol mass spectrometer (SP-AMS) from Jinan University was deployed in urban Guangzhou site, running between V-mode with laser on and V-mode with laser off modes. Two-month aerosol data were collected using SP-AMS, together with SMPS, HR-ToF-AMS and aethalometer for BC. Here we report the very new and first result from SP-AMS during GBA2018, including the chemical composition, size distribution, and mass concentration of measured aerosol particles. Events of PM-polluted days will be investigated. BC represented by Cx family ions will be compared to the results from aethalometer. The finger prints of non-refractory (NR) organics (laser off mode) and BC-coating plus NR organics (laser on mode) in the urban aerosol in GBA will be discussed.

Formation of Inorganic Sulfate from Organosulfur Compounds through the Heterogeneous OH Oxidation

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Abstract:

Organosulfur compounds are important class of organic species in ambient organic aerosols. While the atmospheric abundance and formation mechanisms have been extensively investigated, the chemical transformation or aging of these compounds remains to be elucidated. Methanesulfonic acid ($\text{CH}_3\text{SO}_3\text{H}$, MSA), formed through oxidation of dimethyl sulfide, is known to represent a major natural source of sulfur in marine environment. Apart from the MSA, organosulfates are another important class of organosulfur compounds. In this work, two small C1 organosulfur compounds (MSA and sodium methyl sulfate, $\text{CH}_3\text{SO}_4\text{Na}$), were selected as model compounds to investigate how organosulfur compounds chemically transform through heterogeneous OH oxidation using an aerosol flow tube reactor. Aerosol mass spectra were obtained by a high-resolution mass spectrometer coupled to a soft atmospheric pressure ionization source (direct analysis in real time, DART). For both C1 organosulfur compounds, there was a significant increase in signal intensity of bisulfate ions (HSO_4^- , m/z 97) after oxidation. We propose that sulfite ($\text{SO}_3^{\bullet-}$) and sulfate radical anions ($\text{SO}_4^{\bullet-}$) chemistry are likely responsible for the chemistry and formation of inorganic sulfate ions upon oxidation for MSA and sodium methyl sulfate, respectively. Furthermore, heterogeneous OH oxidation with these two organosulfur compounds were efficient. The importance of the cycling between the organosulfur compounds and inorganic sulfates through heterogeneous OH oxidation will be discussed.

Dynamic deliquescence process of aerosols by the upward RH pulse mode

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Abstract:

The deliquescence process of atmospheric aerosols, which indicates the phase transition from solid particles to aqueous droplets, has significant effects on solar light scattering and atmospheric chemistry. In this work, a vacuum FTIR spectrometer combined with a relative humidity (RH) pulsed controlling technique is used to in situ observe the deliquescence process and determine the particle phase state for NaCl and (NH₄)₂SO₄ particles with a subsecond time resolution. This method allows us to monitor water content both of gas phase and particle phase, which make it possible to understand the kinetics of deliquescence. The anhydrous NaCl and (NH₄)₂SO₄ particles are deliquesced step by step as the RH changing rapidly in the upward pulse mode. During the deliquescence process, the mass growth factors (MGFs) of particles increase sharply when the RH increases to the deliquescence relative humidity (DRH), meaning the phase transition from a number of solid particles to partially deliquescent particles, which contain both liquid water phase and solid particle phase, and subsequent phase transition from a number of partially deliquescent particles to liquid droplets, along with the water absorption of existing droplets. Meanwhile, the MGFs decrease sharply with the decreasing RH and return to the constant values when the RH arrives at the constant RH. We suggest that a recrystallization process, which indicates the phase transition from partially deliquescent particles to solid particles, occurs with the decreasing MGFs. Further, the research on the deliquescence kinetics is significant for determining either the bulk diffusion or the mass transfer of water vapor in the gas phase mainly limits the deliquescence rate of aerosol particles.

Abundance of Organosulfur in Atmospheric Humic-like Substance

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Abstract:

Sulfation by inorganic sulfate (SO_4^{2-}) provides an effective pathway for “moving” volatile and semivolatile organic compounds from gas-phase to the particle phase. Assessing the importance of this pathway needs quantitative data of OS. We measured the total OS content in the water extracts of ambient fine particulate matter ($\text{PM}_{2.5}$) collected over a year at an urban location in the Pearl River Delta, China. The water extracts were removed of inorganic sulfate before submitting to elemental sulfur analysis using an inductively coupled plasma-optical emission spectrometers (ICP-OES). The water OS isolated using this approach ranged from 0.018-0.160 $\mu\text{g}/\text{m}^3$, about 0.6-4.2% of inorganic sulfate_S or 0.6-4.0% of total sulfur. If a molecular weight of 300 is assumed for an average OS compound, the OS compound mass was estimated to be $0.527 \pm 0.305 \mu\text{g}/\text{m}^3$, accounting for $3.22 \pm 0.94\%$ organic matter. The bulk water-soluble OS is positively correlated with both SO_4^{2-} ($R^2: 0.57$) and OC ($R^2: 0.70$), hinting the association of OS with its precursors. OS content is also positively correlated with known secondary organic aerosol (SOA) tracer (e.g., β -caryophyllinic acid and phthalic acids), consistent with a secondary origin.

Characterization of primary organic aerosols and secondary organic aerosols from heated fatty oils

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Abstract:

Cooking emission is thought to be originated from primary sources, which contributes a large proportion of organic aerosol in urban areas. Cooking may also be a large source of secondary organic aerosol (SOA) because abundant volatile organic compounds (VOCs) generate from the cooking process. In this study, online measurement was performed to study the emission of primary organic aerosol (POA) and formation of SOA from four fatty oils (eg: lard, beef, chicken oils and butter) heated at two most commonly used cooking temperatures (160 and 180°C). Potential aerosol mass (PAM) chamber was used to investigate SOA formation from oxidation reaction of VOCs. OA was characterized by high-resolution time-of-flight aerosol mass spectrometer (HR-TOF-AMS), POA emission rates and SOA production rates showed high oil type and temperature dependences, beef oil showed the highest POA emission rates, less POA emitted from lard oil while SOA formation potential is high, oils at lower temperature need higher OH exposure to reach the maximum SOA production rate. SOA formed from heated fatty oils are less than those from heated vegetable oils at a similar OH exposure range. Acrolein as the detected most abundant alkenal SOA precursor accounts for 0.2-13.6% of the observed SOA. SOA data set measured herein shows an increase in oxygen-containing ion groups (m/z s 28, 29, 44) in mass spectra after aging and follows a linear trend with a slope of approximately -0.3 in the Van Krevelen diagram, which may indicate the chemical evolution of SOA involving the addition of both carboxylic acid and alcohol or peroxide functional groups without fragmentation and/or the addition of carboxylic acid functional groups with fragmentation.

Urban and Rural Difference of SOA Tracer Characteristics in Korea

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Abstract:

Organic Aerosol that consists ultrafine particles in the atmosphere is categorized into Primary Organic Aerosol(POA) and Secondary Organic Aerosol(SOA) according to source. SOA is formed by chemical reaction process of Volatile Organic Compounds (VOCs) with oxidative compounds in the atmosphere. SOA tracer method is widely used to estimate the amount of SOA in the atmosphere for each precursor, based on specific secondary organic compounds produced from each VOCs in the atmosphere. Since VOCs emissions of urban and rural sites are different, the distribution and type of SOA might be different from site to site.

Previous studies have identified several SOA tracers in PM_{2.5} samples and these are categorized into two groups: One is SOA tracers of biogenic VOCs such as isoprene, α -pinene, β -caryophyllene. The other is SOA tracers formed by anthropogenic VOCs including naphthalene and toluene. In this study, we found that SOA tracers originated from biogenic VOCs were more dominant at rural sites and showed high concentration in the summer, while SOA tracers formed by anthropogenic VOCs reaction were not detected well in the atmosphere of rural site but showed well in winter.

Now, we are trying to understand the type and distribution of SOA tracers of biogenic VOCs and anthropogenic VOCs in the Seoul, a representative urban site in Korea and then compare them to the results analyzed at a rural site. Through this result, we will discuss the difference of SOA tracer distribution and characteristics between urban and rural sites in Korea.

Chemical Transformation of Erythritol Aerosols through Heterogeneous OH Oxidation: Kinetics, Chemistry and Reaction Products

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Abstract:

Chemical Transformation of Erythritol Aerosols through Heterogeneous OH Oxidation: Kinetics, Chemistry and Reaction Products

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2-methylerythritols have been chosen as tracers for quantifying the abundance of isoprene derived secondary organic aerosols. While they have often assumed to be relatively unreactive, it is not clear how and to what extent these tracers chemically transform in the atmosphere. To gain more insights into the chemical stability of these tracers in the atmosphere, we investigate the heterogeneous OH oxidation of pure erythritol aerosols, a surrogate for 2-methylerythritols in an aerosol flow tube reactor at a high relative humidity of 85% by identifying the reaction products and quantifying the kinetics. A soft atmospheric pressure ionization source (Direct Analysis in Real Time, DART) coupled with a high resolution mass spectrometer is employed to characterize the reaction products at a molecular level in real time. Aerosol mass spectra reveal that for the OH oxidation with erythritol, C4 functionalization product (C₄H₈O₅) and C3 fragmentation product (C₃H₆O₄) are the major reaction products. The hydrogen abstraction by OH radical likely occurs at the carbon atom bonded with hydroxyl groups, followed by reaction with oxygen molecules, forming peroxy radicals. The self-reactions of two RO₂ can generate the C4 functionalization products through functionalization processes such as Russell mechanism. Alternatively, alkoxy radicals can be generated from the peroxy-peroxy radicals reactions and undergo decomposition to form the C3 fragmentation product. After OH oxidation, the aerosol diameter has been found to decrease by 7.5 ± 0.5 %, suggesting that fragmentation and volatilization processes are major pathways. This could be explained by that erythritol contains multiple hydroxyl functional groups, which likely enhance the formation and decomposition of alkoxy radicals upon oxidation. By quantifying the decay of erythritol upon oxidation, the effective OH uptake coefficient, γ_{eff} , is determined to be 0.45 ± 0.11 , suggesting a chemical lifetime against heterogeneous OH oxidation

of 14.3 ± 0.33 days. The heterogeneous oxidative processes could be a quite efficient removal process for erythritol and likely 2-methylerythritols and might need to be considered in the aerosol source apportionment and modeling studies.

Observation of Cloud Water Chemistry in the Free Troposphere at the summit of Mt.Fuji

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Abstract:

Cloud could affect global water circulation and reflect part of solar radiation to increase the global albedo of the earth. It is difficult to estimate the indirect aerosol climate forcing by satellite-based observation due to uncertainties in both satellite data and methods, so more information between cloud water chemistry and cloud microphysics by high elevation-based observation are needed. Cloud/fog water chemistry has been studied at high elevation sites in North America, EU, and Japan from 1980's to 2000's. However, these studies have been done in the atmospheric boundary layer and information on cloud water chemistry in the free troposphere are limited, which is the atmospheric layer more than 2000 m a.s.l. with the hemispheric background concentrations of various chemicals, and the route of intercontinental flow of air pollutants.

Mt. Fuji is an isolated peak and its summit is located in the free troposphere. We could observe the background air and transboundary air pollutants in the free troposphere from Asian continent. The pathways and source regions of each air mass affect the characteristics of atmospheric aerosol and cloud water chemistry. To clarify cloud water chemistry, we have performed summer observational campaign at the summit of Mt. Fuji (3776 m a.s.l.) and the whole year observation at the southern foot of Mt. Fuji (1300 m a.s.l.) from 2006.

Cloud water samples were manually collected by a passive string-type cloud water collector. The pH and electric conductivity were measured after the filtration by 0.45 μm membrane filter. Major inorganic ions were measured by ion chromatograph and HCO_3^- by TOC analyzer. Fifty-six trace metals

including sixteen rare earth elements (REEs) were measured in 2018 by ICP-MS while Hg was measured by a reducing-vaporization mercury analyzer. The origin of air mass was determined by the backward trajectory and classified three types, i.e. Continental, maritime air, and others.

The volume weighted mean pH of summer cloud water was 4.73 (n=27), 4.78 (n=39) and 4.59 (n=47) during three years from 2016 to 2018, respectively. The average concentration of non-sea salt SO₄²⁻ (nss-SO₄²⁻) was 45.4 µeq/L during recent four years from 2014 to 2018 and was 60.9 µeq/L during nine years from 2006 to 2013, respectively, while the average concentration of NO₃⁻ was 37.6 µeq/L and was 36.1 µeq/L, respectively. This result suggests 25 % reduction of nss-SO₄²⁻ concentration in cloud water probably due to the continuous reduction of SO₂ emission from 2005 in China and the reduction of transportation. However, the concentrations of total inorganic ions and dissolved trace metals in cloud water increased with the decrease of pH values when air mass came from the Continental air. The concentration of REEs in cloud water was also higher in the air mass from the Continental air than in Maritime airmass, and there were high correlations between REEs and nss-SO₄²⁻ and some trace metals such as As, Se, and Cd ($r > 0.903$) in 2018. China occupies 80 % of the production of REEs, so they are good tracers of the long-range transportation from China.

Degradation of PAHs during long range transport simultaneously measured at Tuoji island, China and Cape Hedo, Japan

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Abstract:

The objective in this study is to investigate a degradation of PAHs during long range transport. Aerosols were collected simultaneously at the following three sites, i.e., Tuoji Island, China, Fukue Island and Cape Hedo, Okinawa, Japan in April, October and December, 2012 to 2014. PAHs were analyzed with GC-MS. We identified the air mass passed over the three sites in the same episode, and analyzed our measurement data combined with a CTM model and back trajectory analyses. The contribution of the air mass from China to Cape Hedo passing over Tuoji Island was investigated. In order to estimate the relative contribution, the concentrations of PAHs in Tuoji Island and Cape Hedo were normalized with Elemental Carbon. In autumn and winter, PAHs transported from Tuoji to Cape Hedo were not completely decomposed by ozone reactions and/or photolysis. It was pointed out that coating with organic substances shields PAHs from oxidation by ozone (Shrivastava et al., 2017). According to Takami et al., (2007), aerosols transported from China to Cape Hedo are internally mixed with organic aerosols (OA). Thus, the OA coating was assumed to prevent the degradation of PAHs. Furthermore, it was also assumed that the lifetime of PAHs should be different depending on the chemical components in the OA coating. Therefore, the positive matrix factorization analysis was carried out to identify major sources of OA coating which controls the lifetime of PAHs. In spring and winter, the contribution of vehicle emissions was higher in Tuoji Island than in Cape Hedo. In contrast, the contribution of coal combustion was higher in Cape Hedo than in Tuoji Island. Because the chemical compositions in the OA coating are

different in each source, the contribution of each source differs at both the sites. It was suggested that the aerosols derived from coal combustion in China had a longer lifetime compared to those from vehicle emissions.

Source indicators of biomass burning associated with water soluble ions and anhydrosugars during smoke haze period in Upper Northern Thailand

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Abstract:

The northern region of South East Asia (SEA) including Upper Northern Thailand (UNT) has been faced with air pollution in forms of smoke haze in almost every dry season due to large scale biomass open burning in the region. Backward trajectories indicated that air masses originated in the west and southwest directions mainly influenced air quality in UNT. Water soluble ions and anhydrosugars were quantified in fine particulate (PM_{2.5}) samples, which were collected in urban area of Chiang Mai, Thailand in dry season (March to April 2016). The samples were collected on quartz fiber filters by using mini volume (5.0 L min⁻¹) air samplers on daily basis (24-hours sampling). The average PM_{2.5} concentrations (n = 60) during the study period were 64.3±17.6 µg m⁻³. Daily average PM_{2.5} concentration was 82% (49 days) exceeded the Thailand National Ambient Air Quality Standard (50 µg m⁻³). The major water soluble ions found in PM_{2.5} samples were SO₄²⁻, NH₄⁺ and NO₃⁻ with the average concentrations of 8.73±2.88, 3.32±1.01 and 2.70±0.51 µg m⁻³, respectively. Relatively high concentrations of biomass burning tracers including K⁺ (1.27±0.38 µg m⁻³) and levoglucosan (1.22±0.75 µg m⁻³) were found. Strong correlations between PM_{2.5}-K⁺ (r = 0.764), PM_{2.5}-levoglucosan (r = 0.800) and between the two biomass burning tracers (r = 0.819) were found. A scatter plot of Levoglucosan/K⁺ versus Levoglucosan/Mannosan ratio indicating that biomass-burning tracers in this study could be emitted from forest fires and agricultural wastes burning.

EMISSION CONTROL MEASURES AFFECTED PM_{2.5} CONCENTRATION AND COMPOSITION DURING THE 2014 YOUTH OLYMPIC GAMES IN NANJING

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Abstract:

In China, emission control measures have been implemented to improve air quality during large events, such as the Youth Olympic Games (YOG) in August 2014 in Nanjing. In this work, six measurement campaigns between January 2014 and August 2015, conducted prior, during, and after the YOG, were undertaken in Nanjing to determine the effects of emission controls and meteorological factors on PM_{2.5} concentration and composition (Miettinen et al., 2019). A secondary objective of the research was to detect possible changes in the sources of the PM_{2.5} by investigating the source-specific markers and indexes. PAHs, OPAHs, hopanes, n-alkanes, heavy metals and several other inorganic elements were measured from a total of 100 PM_{2.5} filter samples. In addition, air temperature, relative humidity, wind speed, wind direction, rainfall, and solar radiation were predominantly measured continuously during the campaigns. The sampling station, previously described in Jalava et al. (2015), was at the Nanjing University Xianlin campus (N 32°07.152', E 118°56.918'). The HYSPLIT model (Stein et al., 2015; Rolph et al., 2017) was used to calculate backward 3-D trajectories for the air masses arriving in the measurement site at each full hour during the campaigns.

Regional atmospheric transport and meteorological parameters partly explained the observed differences between the campaigns, but the emission control measures were the main factor behind the improved air quality during the YOG. Emission controls substantially reduced concentrations of PM_{2.5} (31 %), total PAHs (59 %), OPAHs (37 %), and most heavy metals (44–89 %) during the YOG compared to August 2015. However, variances between individual components were observed, e.g., concentrations of potentially more harmful OPAHs decreased less than concentrations of PAHs. The most abundant PAHs and OPAHs were benzo[b,k]fluoranthenes, fluoranthene, pyrene, chrysene, 1,8-naphthalic anhydride, and 9,10-anthracenedione in all campaigns. Carbon preference index and the contribution of wax n-alkanes indicated mainly biogenic sources of n-alkanes in May–June 2014 and anthropogenic sources in the other campaigns. Hopane indexes pointed to vehicular transport as the major source of hopanes, but contribution of coal combustion was detected in winter 2015.

The results show that the relatively strict emission control measures undertaken during the YOG were effective in reducing air pollution. Interestingly, also the proportions of health-hazardous components in PM_{2.5} changed due to emission control measures. Consequently, this may change the toxicity of the PM_{2.5}. In the future, more closely linked aerosol chemistry, physics, and toxicology research is needed

to achieve a realistic overall picture of the effectiveness of emission control measures on the reduction of adverse health effects of PM_{2.5}.

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Co-spray drying of silver nanocolloids and target molecules for surface-enhanced Raman spectroscopy

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Abstract:

Surface enhanced Raman spectroscopy (SERS) is highly sensitive analytical method to detect target (analyte) molecules which absorbed on metal nanostructures (nanoparticles) with a characteristic length of around 50nm. In order to achieve high SERS activity down to single molecular level, it is important to control the complex structure between target molecule and metal nanoparticle. In this study, co-spray-drying method is applied to fabricate a well-controlled structures between target molecule (existing in atmospheric environment) and metal nanoparticle (Ag nanoparticles). Ag nanocolloids with average diameter of 50nm dispersed in water was mixed with major chemical components of atmospheric particles such as ammonium sulfate, nitrates and organic compounds. During the evaporation of the solvent, target molecules are accumulated on the surface of Ag nanoparticles and they create complex structure. The agglomerate structure was also controlled by changing the number concentration of the colloid, i.e., number of Ag nanoparticles per droplet. The effect of SERS activity on the molecular species, concentration, number ratio between target molecules/Ag were evaluated experimentally.

Analysis of polycyclic aromatic hydrocarbons and their nitro-derivatives by using HPLC-fluorescence developed method

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Akira Toriba

Abstract:

Analysis of polycyclic aromatic hydrocarbons and their nitro-derivatives by using HPLC-fluorescence developed method

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Abstract: The high-performance liquid chromatography (HPLC) with fluorescence (FL) developed method was successfully applied to the simultaneous analysis of polycyclic aromatic hydrocarbons (10PAHs) and nitro-derivatives of PAHs (18NPAHs) in airborne particulate. The limits of detection (LODs) were 0.1 - 9.2 pg per injection for PAHs and 0.1 - 140 pg per injection for NPAHs. For validation, the method was applied to analyze crude extracts of fine particulate matter (PM_{2.5}) samples and achieved good analytical precision and accuracy. Additionally, the proposed method was verified on the standard reference material (SRM1649b, urban dust); the experimentally analyzed and observed the concentrations of PAHs and NPAHs were similar to those in previous reports. Thus, the method developed herein has the potential to become a standard HPLC-based method, especially for NPAHs compound. HPLC system developed of this study consists of an on-line clean-up and reduction for NPAHs in the 1st dimension, and separation of the PAHs and the reduced NPAHs and their FL detection in the 2nd dimension after column-switching. To identify an ideal clean-up column for removing sample matrix that may interfere with detection of the analytes, the characteristics of eight reversed-phase columns were evaluated. The nitrophenylethyl (NPE)-bonded silica column was selected because of its shorter elution band and larger retention factors of the analytes due to strong dipole-dipole interactions. The amino-substituted PAHs (reduced NPAHs), PAHs and deuterated internal standards were separated on polymeric octadecyl-bonded silica (ODS) columns and by dual-channel detection within 2 hour including clean-up and reduction steps. Moreover, the developed HPLC-FL detection was applied to analyzed PM samples from biomass burning in Thailand.

Keywords: Polycyclic Aromatic Hydrocarbons, HPLC-Fluorescence, Biomass burning, Airborne Particulate Matter

Individual Particle Analysis of Aerosol Particles Collected at Mt. Fuji in the Summer of 2018

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Abstract:

Atmospheric aerosol particles play an important role in the climate change, because they absorb and scatter the solar radiation and form clouds by acting as cloud condensation nuclei. However, scientific understanding of atmospheric aerosol behavior is not sufficient (IPCC, 2013). Especially, the features of particles can largely change through long-range transport. In order to reveal the characteristics of the long-range transported particles, we collected aerosol particle samples at Mt. Fuji.

The collection of the aerosol particles was made at both summit and middle of Mt. Fuji (3776 m a.s.l. and 1300 m a.s.l., respectively) in Japan during summer in 2018. The summit of Mt. Fuji often located in the free troposphere and both observatories were strongly influenced by the polluted airmasses transported from Asian continent and by the local emissions in the planetary boundary layer (PBL). Size, shape and chemical compositions of individual particles were analyzed by using a transmission electron microscope equipped an energy dispersive X-ray spectrometer. The backward trajectories were computed by using the HYSPLIT trajectory model (https://ready.arl.noaa.gov/HYSPLIT_traj.php).

Sulfates and modified sea-salt particles were dominant in most samples from both the summit and the middle of Mt. Fuji. In the samples at the middle of Mt. Fuji, a number of sulfates included black carbon, which was mainly emitted from the anthropogenic sources such as, combustions of fossil fuel. Five days backward trajectory analyses showed that air masses passed over the central Japan. This result indicated that the middle of Mt. Fuji was affected by local anthropogenic emission. Some samples were collected during new particle formation (NPF) events occurring at the summit of Mt. Fuji. One of these samples included microparticles with about 100-200 nm and their main chemical composition was S. Since H₂SO₄ is as known as the principal specie dominating during NPF events, it is hypothesized that these particles were produced by -NPF. Our result from single particle analyses will help to understand the mechanism of NPF.

Characteristics of organic compounds in PM_{2.5} aerosols during high concentration events measured in Seoul, Korea

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Abstract:

Fine particulate matter (PM_{2.5}) which is one of the major air pollutants, is emitted by diverse anthropogenic and natural sources and impacts on climate change directly or indirectly. Furthermore, PM_{2.5} is classified as carcinogenic to humans (IARC Group 1) and is able to trigger adverse health effects on cardiovascular, respiratory, and central nervous systems. PM_{2.5} is composed of varied constituents such as water-soluble ions, heavy metals, elemental carbon, and organic carbon. Organic carbon contains various organic compounds which have different emission characteristics depend on each emission source. Thus, identifying the emission characteristic is possible by characterizing the concentration of organic compounds. The aim of this study is to analyze property of PM_{2.5} and to characterize the concentration of organic compounds in PM_{2.5} collected from May 2016 to February 2017 in Seoul, Korea by using the sonication extraction method.

The sampling site was located on the rooftop of the former building of Graduate School of Public Health in Seoul National University (17m above ground, 37.581°N, 127.001°E) in Seoul, Korea. The sampling site is in the center of Seoul and is surrounded by commercial buildings, residential areas, and surface roads. For the analysis of organic compounds, PM_{2.5} samples were collected using the high volume air sampler (TE-HVPLUS, TISCH, USA). Before the sampling, quartz filters (QMA 1851-865, 203mm X 254mm, Whatman, UK) were baked at 450°C for 12 hours to remove pre-existing organic matters. The pre-baked filter was loaded on the sampler with impactor filter (TE-230-QZ, TISCH, USA) to collect particulate matters less than 2.5 μm.

For sample extraction, quartz filters collected PM_{2.5} sample is extracted by using sonication method. In the sonication method, samples were extracted with 30 mL mixture of dichloromethane and methanol (3:1, v/v) for 30 minutes. This procedure was repeated once more. The extracts were concentrated to 1 mL by using nitrogen gas using TurbovapII (Caliper Life Sciences, USA). Final concentrates were

analyzed by gas chromatography/mass spectrometry (GC/MS) (7890A/5975C, Agilent Technologies, USA).

Quantification and Molecular Characterization of Atmospheric Brown Carbon by LC-HRMS

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Abstract:

Quantification and Molecular Characterization of Atmospheric Brown Carbon by LC-HRMS

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Abstract

Light-absorbing components of organic aerosol, which are abbreviated as “brown carbon” (BrC), can effectively absorb light in the ultraviolet-visible range and affect atmospheric visibility and radiation balance. It is significant to clarify the chemical composition, absorbance characteristics, formation and transformation mechanisms of BrC components for atmospheric radiative forcing, air quality, and climate impact. The identification of BrC components is a great challenge due to its complex composition of organic aerosol. Liquid chromatography high-resolution mass spectrometry (LC-HRMS) provides a possibility for analyzing the detailed composition of complex organic systems. This study quantified and characterized BrC components in atmospheric organic aerosols using LC-Orbitrap MS combined with electrospray ionization (ESI) and atmospheric pressure ionization (APPI) sources. The chromatographic separation of BrC components with LC, characterization of their light-absorbing with photo-diode array (PDA) detector, and its chemical composition analysis with HRMS. The results show that BrC components is an important part of organic aerosol. Polar and nonpolar BrC components could be detailed characterization through multi-ionization sources. In particular, we found that oxygenated and nitrated aromatic compounds are the main light-absorbing BrC components, indicating that aromatic compounds emissions from vehicle and fossil fuel combustion may be an important precursor of BrC components.

Additional keywords: brown carbon, quantification, molecular characterization, UPLC-PDA-Orbitrap MS.

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Identification of Tautomer of Phthalic Anhydride in Atmospheric Aerosols by TIMS TOF MS

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Abstract:

ABSTRACT

In recent years, high resolution mass spectrometry has been applied more and more in the study of the molecular composition of organic compounds of atmospheric aerosols. Electrospray ionization (ESI) is a commonly used ion source for high resolution mass spectrometry. When we use ESI, the ionization of organic compounds is not only selective but also competitive ionization mechanism exists among compounds. Therefore, the ESI ionization condition will directly affect the results of high resolution mass spectrometry analysis. In this study, phthalic anhydride in atmospheric aerosol samples selected from Beijing in 2017 was identified by trapped ion mobility time-of-flight mass spectra (TIMS TOF MS). We found phthalic anhydride had tautomers in summer aerosols sample, but no tautomers were detected in winter samples. By investigating the ionization conditions of phthalic anhydride standard compounds when we use +ESI, it was found that tautomers can be produced under certain ionization conditions. However, the detection of tautomers of phthalic anhydride in summer aerosols sample is not under this ionization condition. Therefore, we hypothesize that the presence of one or some of the compounds in the aerosols may affect the ionization of phthalic anhydride, forming a tautomer during ionization. The structure of the phthalic anhydride tautomer and the formation of which compound are affected require further investigation.

ACKNOWLEDGE

This work is supported by the National Natural Science Foundation of China (21577175, 91543130).

A Facile Quantification of Hyaluronic Acid and its Crosslinking Using Gas-Phase Electrophoresis

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Abstract:

We report a facile, high-resolution aerosol-based electrophoretic approach to quantitatively characterize hyaluronic acid (HA) and study its crosslinking reaction. Electro-spray-differential mobility analysis (ES-DMA) was employed, where mobility size distributions, number concentrations, molecular mass distributions and polydispersity index of HAs were obtained successfully by ES-DMA. Orthogonally, size exclusion chromatography (SEC) was employed for data comparison on a semi-quantitative basis. Using ES-DMA, the 1,4-butanediol diglycidyl ether (BDDE)-induced crosslinking of HA was also able to be successfully characterized through a time-dependent study. This prototype study demonstrates that ES-DMA as a new method for a rapid quantitative characterization of HA and its derivative product and providing a capability of real-time monitoring of the HA-crosslinking during the formulation process.

Temporal patterns and source apportionment of PM_{2.5}-bound Polycyclic aromatic hydrocarbons: a case study of Anshan, a typical steel industry city in northeast China

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Abstract:

In order to explore the temporal distribution characteristics and sources of 16 PAHs bound to PM_{2.5} in Anshan atmospheric environment, intensive seasonal sampling campaigns were undertaken at five locations in Anshan, Liaoning province, in which median-volume samplers were used to collect particulate-phase polycyclic aromatic hydrocarbons (PAHs) by mean of filter membranes. Samples were analyzed via gas chromatography in combination with mass spectrometric detection (GC/MS EI, Agilent 6890N-5975). Results showed that the total concentration of 16 PAHs in PM_{2.5} in winter (286.93 ng/m³) of Anshan City was significantly higher than that in other three seasons, followed by spring (40.71 ng/m³) and autumn (32.70 ng/m³), and the lowest in summer (11.20 ng/m³). What's more, the mean concentration of benzo[a]pyrene in PM_{2.5} in winter was 19.77 ng/m³, which was significantly higher than the daily mean concentration limits of the Chinese national ambient air quality standard (GB3095-2012) (2.5 ng/m³). After normalization, the highest content of 16 PAHs in PM_{2.5} was benzo[b]fluoranthene, followed by fluoranthene and pyrene, and the lowest was acenaphthene. The diagnostic ratios were used for identifying and assessing pollution emission sources of PAHs in PM_{2.5}. Through the ratio of benzo[a]anthracene/(benzo[a]anthracene+chrysene), it can be concluded that the contribution of combustion sources for grass, wood and coal to the emission of PAHs was higher. A PMF-CMB combined model was used to identify the sources of PAHs in PM_{2.5} in Anshan. Firstly, the PMF model showed that coal combustion, dust sources, vehicle exhaust, coke dust, biomass combustion and other sources of pollution were the major sources for PAHs, accounting for 26.3 %, 24.6 %, 21.9 %, 18.0 %, 6.3 % and 3.0 %, respectively. Then, the CMB model was used to analyze the source of mixing source (dust sources), and the contribution of soil dust, road dust, storage dust and construction dust were obtained, respectively. Finally, integrating the two results of PMF model and CMB model, it can be concluded that coal combustion, dust sources, vehicle exhaust were the mainly sources for PAHs in PM_{2.5} in Anshan.

Chemical speciation of chromium in atmospheric particulate matter collected with filter and cyclone by XAFS method

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Abstract:

Atmospheric particulate matter is seriously concerned for human health effects. There are substances whose hazards change due to the difference in chemical composition. For example, transition metals such as iron and chromium changes their toxicity depending on the oxidation state. Therefore, it is necessary to focus on not only particle mass but also chemical composition. We focus on chromium which exists in different chemical states such as Cr(0), Cr(III) and Cr(IV) in the atmosphere. In particular, Cr(VI) is more toxic compared with others. Therefore, analysis of the detailed chemical state of chromium is important.

Generally, sequential extraction procedure has been used for discriminating composition of toxic chromium in the atmosphere. However, this method has a problem of low detection sensitivity. Therefore, we conducted an experiment of examining chromium speciation by using the X-ray absorption fine structure (XAFS) method. There are two major advantages of XAFS for analysis. First, this method is nondestructive because any preparations such as extraction are not required. Second, this method can distinguish different compounds of the same element, including different oxidation state. Consequently, the toxicity of chromium present in the atmospheric particulate matter would be evaluated in detail by XAFS method.

In this study, atmospheric particulate matter was collected using quartz fiber filter. In addition, aerosol particle was also collected in powder form by using simultaneous sampler for fine and coarse particles that consists of the virtual impactor and the cyclones. Approximately 20 mg of the powder sample and 300 mg of cellulose powder were subjected to 50 kN press to produce layered pellet. Then, XAFS spectra of the pellet and filter samples were obtained by irradiating synchrotron radiation at SAGA Light Source. We focused on XANES spectrum because spectral difference for chromium compounds appears remarkably in this range. To identify what types of chromium were present in our samples, the obtained XANES spectra was applied to the linear combination fitting based on the XANES spectra of standard samples of chromium.

As a result, it was found that the quality of XANES spectrum obtained from pellet of the aerosol powder is better than the filter sample. Furthermore, the results of the linear combination fitting suggested a possibility that Cr(VI) was present in the atmospheric particulate matter.

In-depth analysis of high PM_{2.5} pollution during March 2018 in Gwangju, Korea

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Abstract:

Semi-continuous measurements of PM_{2.5} and its major chemical species, such as carbonaceous and water-soluble ionic components, were made during the period from March 10 to April 09, 2018, at an air pollution intensive monitoring station in Gwangju, Korea. In addition, 24-hr integrated PM_{2.5} and size-resolved samples were collected to analyze the concentrations of organic and elemental carbon (OC and EC), water-soluble OC (WSOC), humic-like substances (HULIS), and water-soluble ionic species. This study was aimed to investigate the driving chemical species and the formation processes of PM_{2.5} observed during high pollution episode. Over the study period, a total of 9 PM_{2.5} pollution days, which exceeded 24-hr Korean PM_{2.5} standard (35 $\mu\text{g}/\text{m}^3$), occurred. In particular, 24-hr average PM_{2.5} concentration on March 24 was 91.9 $\mu\text{g}/\text{m}^3$, which was attributed to highly elevated concentrations of SO₄²⁻, NO₃⁻, and NH₄⁺. MODIS images, synoptic charts, and air mass backward trajectories supported the significant impact of long-range transportation of air pollutants from northeastern China during pollution episode. Furthermore, stable meteorological conditions such as a high pressure, low wind speed and high relative humidity were likely important factors for secondary formation of water-soluble chemical species by aqueous-phase reactions of SO₂, NO₂, and NH₃, resulting in PM_{2.5} increase. Concentrations of NO₃⁻ and SO₄²⁻ during the pollution episode increased more significantly than those of their gaseous precursors. NO₃⁻ and SO₄²⁻ concentrations increased by 10.6 and 11.6 times from background period to pollution period, respectively; while there was only a 1.9-fold and 1.0-fold increase in NO₂ and SO₂ concentrations. These results suggested the enhanced secondary transformation of NO₂ and SO₂ during PM_{2.5} pollution period. The NO₃⁻, SO₄²⁻, NH₄⁺, WSOC, and HULIS exhibited mostly bi-modal size distributions peaking at 1.0 and 6.2 μm , with predominant droplet modes. In particular, outstanding droplet mode size distributions were observed on March 25 when a severe pollution episode occurred due to stable air conditions and long range transport of aerosol particles from northeastern regions of China. From the size distribution of K⁺ in accumulation mode, it

can be inferred that in addition to the secondary organic aerosol formation, accumulation mode WSOC and HULIS could be partly attributed to biomass burning emissions.

Characteristics of carbonaceous aerosols in North China Plain during Winter haze

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Abstract:

A field campaign was conducted in January and November of 2018 to explore the Winter haze in North China Plain. The sampling site is located in Gucheng, Hebei Province, which is about 110 km from Beijing. Carbonaceous aerosols were measured by an Aethalometer (AE33) and a Sunset online ECOC analyzer. In January, the average OC and EC were 53.22 ± 39.30 and 8.37 ± 5.98 $\mu\text{g}/\text{m}^3$, respectively. In November, the average OC and EC were 31.76 ± 22.82 and 6.54 ± 3.86 $\mu\text{g}/\text{m}^3$, respectively. In this study, the minimum R squared (MRS) method was adopted to determine the primary OC/EC ratio, $(\text{OC}/\text{EC})_p$ and the primary mass absorption efficiency (MAEp) of elemental carbon (EC). $(\text{OC}/\text{EC})_p$ was 4.91 and the average OC/EC ratio was 7.11 ± 3.33 , implying a high content of organic materials from the primary emission. The MAEp ($25 \text{ m}^2/\text{g}$) is very close to the average MAE ($24.09 \pm 10.64 \text{ m}^2/\text{g}$), suggesting a neglectable amplification in EC light absorption.

Characteristic of particulate matter down to PM_{0.1} in Southern Thailand

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Abstract:

Atmospheric particulate matter down to ultrafine particle (particulate matter diameter smaller than 100 nm) from southern Thailand as a case study in Songkhla province are collected by Nano-sampler. The Nano-sampler can be used to sample a greater amount of nanoparticles at ambient pressure. The used sampler carbonaceous components (Elemental Carbon (EC) and Organic Carbon (OC)) in particle matter collected on quartz fiber filter were analyzed by IMPROVE_TOR method; the Interagency Monitoring of Protected Visual Environment using Thermal/Optical Reflectance. The results show that size distribution of ambient particle down to PM_{0.1} from July to October, 2017 around 10% of mass concentration is nano-size particles (<100 nm). The highest mass concentration is coarse mode (PM_{10-2.5}) and the lowest mass concentration is PM_{0.5-0.1}. The OC/EC ratios in nano-aerosol at the sampling site ranged from 1.21 to 2.93. The backward trajectory analysis of air mass arriving at the monitoring station is calculated to confirm the potential sources. Most of air mass come from west and southwest part that represent the ocean clean air and local source.

Investigation of optical properties and chemical characterization of humic-like substances (HULIS) in PM_{2.5} over Xi'an, China

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Abstract:

Spatial distribution of concentration, optical properties and chemical characterization of HULIS in urban fine particulate matter (PM_{2.5}) were investigated during May 2015 to January 2016 in Xi'an. The yearly mean mass concentrations of PM_{2.5}, total carbon (TC, organic carbon (OC) plus elemental carbon (EC)), OC and HULIS-C were $61.6 \pm 29.9 \mu\text{g m}^{-3}$, $11.8 \pm 6.5 \mu\text{g m}^{-3}$, $9.4 \pm 5.3 \mu\text{g m}^{-3}$, and $2.9 \pm 2.1 \mu\text{g m}^{-3}$, respectively. On average, the contributions of HULIS-C to PM_{2.5}, TC, and OC were 6.1%, 27.2%, and 34.5%, respectively. HULIS-C followed a decreasing order as winter > spring > summer > autumn. The UV-VIS absorption spectra of HULIS samples decrease monotonically with decreasing wavelength. The absorption intensity of HULIS followed an decreasing order as winter > spring > autumn > summer. The higher SUVA₂₅₄ and SUVA₂₈₀ indicated more C=C and C=O unsaturated bonds in HULIS samples in winter compared with summer. The E₂/E₃ ratio has a summer maximum and a winter minimum, which further indicated that winter HULIS samples have a greater conjugation and aromaticity than summer HULIS samples. The FTIR spectra further indicated the presence of aliphatic C-H, alcoholic C-OH, non-acidic carbonyl C=O, carboxylic COOH, vinyl, and aromatic rings structures in HULIS samples. There are higher K⁺ and a strong correlation between HULIS-C and K⁺ ($R^2=0.642$) and a strong correlation between HULIS-C and OC₁+OP₂ ($R^2=0.510$) in winter. While correlations between HULIS-C and K⁺ ($R^2=0.004$) and OC₁+OP₂ ($R^2=0.043$) were weak in summer. In addition, all OC/EC ratios during sampling are greater than 2, which suggested secondary reaction are in exist during sampling. SOC in winter is significantly higher than that in summer. These may indicated that biomass burning and secondary formation were mainly sources of ambient HULIS in winter. In summer photosensitized reactions was mainly formation pathway of HULIS because of stronger light which may promote photosensitized reaction and caused generation of HULIS .

An empirical approach towards quantifying black and brown carbon contents from multi-wavelength thermal/optical analysis

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Abstract:

Carbonaceous material (CM) plays an important role in aerosol climate and health effects. Thermal/optical analysis (TOA) quantifies total carbon (TC) in CM deposited on filters and divides it into elemental carbon (EC) and organic carbon (OC) based on thermal stability. A novel thermal/optical analyzer (DRI Model 2015, Magee Scientific, Berkeley, CA, USA) quantifies thermal carbon fractions while simultaneously monitoring filter reflectance and transmittance at 7 wavelengths (405 – 980 nm) throughout the analysis, offering an opportunity to report black carbon (BC), brown carbon (BrC), and non-light-absorbing carbon (NLAC) along with TC, EC and OC concentrations. Multi-wavelength TOA has been applied to > 50,000 samples acquired from 160 sites of the U.S. Interagency Monitoring of Protected Visual Environments (IMPROVE) network in 2016. From the data, a four-step procedure was developed to evaluate BC, BrC, and NLAC. The first step establishes the BC spectral profile from samples with the lowest absorption Ångström exponent (AAE) based on spectral attenuation, yielding a consistent BC AAE of ~0.65 among all sites. Second, spectral attenuations are apportioned into BC and BrC components using the Hybrid Environmental Receptor Model (HERM), which adopts the BC profile as a constraint while estimating the BrC spectral profile that produces the best fit. Providing the BC- and BrC-specific attenuation at 405 nm (i.e., ATN_{405,BC} and ATN_{405,BrC}), the third step estimates BC and BrC mass absorption efficiencies (MAEs) at 405 nm from the upper edge of ATN_{405,BC}-TC and ATN_{405,BrC}-TC scatter plot, respectively. The resulting apparent MAE₄₀₅ of 28.6 m² g⁻¹ for BC and 10.8 m² g⁻¹ for BrC are considered the upper limit of “true” values. Finally, BC and BrC mass based on the corresponding MAEs are added to the BC and BrC spectral profiles. Three profiles, i.e., BC, BrC, and NLAC (only carbon, zero spectral attenuation), can then be used in HERM to apportion TC and all spectral attenuations into the BC, BrC, and NLAC components.

The above procedure was applied, by site, to analyze IMPROVE samples. The three components generally explain > 95% variability in the dataset. BC agrees with EC well with r² of 0.75 – 0.91 and BC/EC ratio of 0.76 – 1.2. A wide range of AAE (1.5 – 3.5) was found for BrC, suggesting different BrC

across the network while this analysis gives the lower-bound estimates of BrC mass. NLAC appears to dominate the TC mass. At the Fresno, California site, for example, BC, BrC, and NLAC accounts for 15%, 12%, and 73% of TC in warm seasons (Apr. – Sep.) and 18%, 18%, and 64% of TC in cold seasons (Oct. – Mar.), reflecting a substantial increase of BrC due to residential wood combustion for heating. Spatiotemporal distributions, particularly the urban-rural contrast, of BC and BrC will be further discussed.

Characteristics and Sources apportionment of Carbon Components in PM_{2.5} During Autumn and Winter in Panjin City

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Abstract:

In order to study the pollution characteristics and sources of carbon components in Panjin City during autumn and winter, the PM_{2.5} samples were collected at three monitoring points in October 2016 and January 2017. Thermal/optical carbon Analyzer (DRI MODEL2001) was used to analyze organic carbon (OC) and element carbon (EC). Pollution characteristics and source of carbon components in PM_{2.5} were analyzed by OC/EC ratio method, EC tracer method, Chemical mass balance (CMB)-Principal component analysis (PCA) method. The results showed that the PM_{2.5} concentration exceeded the daily ambient air quality standard (GB3095-2012), and the average concentrations of OC and EC in autumn were 10.02 $\mu\text{g}\cdot\text{m}^{-3}$ and 3.91 $\mu\text{g}\cdot\text{m}^{-3}$, while in winter were 16.04 $\mu\text{g}\cdot\text{m}^{-3}$ and 5.62 $\mu\text{g}\cdot\text{m}^{-3}$, respectively. According to the OC / EC ratio method, the OC/EC ratios were more than 2.0 during the sampling periods, indicating that there was secondary pollution in autumn and winter. The results of Spearman correlation analysis and linear fitting indicated that the OC and EC sources were complex in Development zone, but in Secondary school and Cultural park may have similar origins during autumn and winter. Secondary organic carbon (SOC) was quantitatively estimated by EC tracer method, and the concentration was 7.21 $\mu\text{g}\cdot\text{m}^{-3}$ and 23.07 $\mu\text{g}\cdot\text{m}^{-3}$ in autumn and winter, absolute and relative errors of SOC uncertainty were 0.98 $\mu\text{g}\cdot\text{m}^{-3}$ and 14.00% in autumn, 1.87 $\mu\text{g}\cdot\text{m}^{-3}$ and 8.21% in winter, respectively. Based on the methods of CMB and PCA method, the carbon components in autumn and winter were mainly derived from coal combustion, biomass burning and vehicle exhaust.

Investigation of absorption properties of aerosol particles and mass absorption cross section of black carbon at an urban site

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Abstract:

In this study, real-time absorption coefficients of carbonaceous species in PM_{2.5} was observed using a dual-spot 7-wavelength Aethalometer between November 1, 2016 and December 31, 2017 at an urban site of Gwangju, Korea. In addition, 24-hr integrated PM_{2.5} samples were simultaneously collected at the same site and analyzed for organic carbon and elemental carbon (OC and EC) using the thermal-optical transmittance protocol. During the study period, two Asian dust (AD) events occurred in April (AD I) and May (AD II), respectively, during which light absorption in total suspended particles was observed. Main objectives of this study were to investigate absorption properties of light-absorbing organic aerosols, which are called brown carbon (BrC), and to estimate mass absorption cross section (MAC) values of black carbon (BC) particles at the study site using the linear regression between aethalometer-based absorption coefficient and filter-based EC concentration. Light absorption coefficients by aerosol particles were found to have 2.7-3.3 times higher at 370 nm than at 880 nm. Monthly average absorption Ångström exponent (AAE_{370-950nm}) calculated over wavelength range of 370-950 nm ranged from 1.10 to 1.35, which was lower than the AAE_{370-520nm} values ranging from 1.19-1.68 that was enhanced due to the presence of BrC. The estimated AAE_{370-660nm} of BrC ranged from 2.2 to 7.5 with an average of 4.22, which was fairly consistent to the values reported by previous studies. The BrC absorption at 370 nm contributed 10.4-28.4% to the total aerosol absorption, with higher contribution in winter and spring and lower in summer. Strong spectral dependence of aerosol light absorption was clearly found during the two AD events. AAE_{370-660nm} of both light absorbing organic aerosols and dust particles during the AD I and II was 4.8 ± 0.5 and 6.2 ± 0.7 , respectively. Higher AAE value during the AD II could be attributed to mixed enhanced urban pollution and dust aerosols. Absorption contribution by the light absorbing organic and dust aerosols estimated at 370 nm to the total light absorption was approximately 19% before and after the AD events, but it increased to 32.9-35.0% during the AD events. The relationship between aerosol absorption coefficients at 880 nm and EC concentrations provided BC MAC value of $15.2 \text{ m}^2/\text{g}$, ranging from 11.4 to $16.2 \text{ m}^2/\text{g}$. Result from this study suggests that if the MAC value recommended by the manufacturer is applied to calculate the equivalent BC concentration and radiative forcing due to BC absorption, they would result in significant errors, implying investigation of a unique MAC value of BC particles at the study site.

Light absorption of brown carbon and its relationship with aerosol chemical compositions in northern China

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Abstract:

Brown carbon (BrC) is a certain type of light-absorbing organic matter which has strong light absorption near ultraviolet (UV) wavelengths, exerting a warming effect on the global climate. However, the impact of BrC on both regional air pollution and climate warming is being ignored in most models because of its complex chemical compositions and mixed emission sources.

Due to the difference of wavelength dependence for BC and BrC, the light absorption of BrC can be segregated from the total absorption measured by a multi-wavelength optical instrument. In this study, the Absorption Ångström Exponent (AAE) method was applied to characterize the light absorption of BrC at an urban site in Beijing. The contribution of BrC to total light absorption was found to show a seasonal variation between winter of 2017 and summer of 2018, possibly relating to different emission sources and chemical compositions. Based on the analysis of typical pollution episodes, the light absorption of BrC under different pollution levels was also investigated to explore the effects of secondary formation on BrC's chemical compositions. Furthermore, together with real-time measurement of particulate chemical compositions measured by an Aerosol Mass Spectrometer (AMS) and source apportionment derived from Positive Matrix Factorization (PMF) model, we applied the Multiple Linear Regression (MLR) model to apportion the contributions of individual primary and secondary organic aerosol source components of BrC absorption.

These results may provide a perspective to understand the characteristics of light absorption contributed by BrC in urban atmosphere and revealed the possible emission sources, which can provide some essential constraints for climate models to estimate the impact of BrC.

An Intercomparison of aerosol absorption coefficient of several instruments in Beijing city

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Abstract:

Aerosol is a light-absorbing substance which absorbs incoming solar radiation and outgoing terrestrial radiation while releasing infrared radiation and heating the surrounding atmosphere. Therefore, the measurement of aerosol absorption coefficient is important to the climate and environment. Our observation from November 7 to December 7 of 2017, including aethalometer (AE-31), the reference photoacoustic extinctions (PAX), CRDS-AURORA (cavity-ring down spectroscopy/AURORA-3000) system, and multi-angle absorption photometer (MAAP), showed different results in Beijing city. AE-31 and MAAP presented a good linear agreement with PAX (coefficient of determination (0.93 for AE-31 and PAX, 0.94 for MAAP and PAX)), so we used PAX data as a reference absorption measurement at 532 nm. However, CRDS-AURORA system wasn't consistent well with PAX. The correction factor, which is required to compensate for the scattering error caused by filter fibers and aerosol particles, was established by AE-31, MAAP and PAX. The factor calculated by AE-31 and MAAP (2.44) is lower than the previously used value (4.0) at 532nm, and the other coefficient which was obtained by AE-31 and PAX might be related to the pollution process.

Characteristics of Carbonaceous aerosols in PM_{2.5} based on Long-term observation at a GAW regional station in Korea

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Abstract:

Carbonaceous aerosols in the atmospheric PM_{2.5} were measured at Anmyeon Island which is a background site in South Korea for 3 years (during the period of June 2015 to June 2018). Carbonaceous aerosols were classified into two fractions, organic carbon (OC) and elemental carbon (EC) based on the thermal optical definition. Water-soluble organic carbon (WSOC) and humic-like-substance carbon (HULIS-C), which are dissolved in the water in OC, were also analyzed.

The annual average OC and EC concentration were $4.19 \pm 2.59 \mu\text{g}/\text{m}^3$ and $0.42 \pm 0.28 \mu\text{g}/\text{m}^3$, respectively, and showed lower concentration in summer than winter. However, OC and EC concentrations showed no clear seasonal variation. During the entire sampling period, the proportions of OC and EC in the carbonaceous aerosols remained constant at OC: 90% and EC: 10%. High OC/EC ratios (10.83 ± 4.17 , ranging from 3.39 to 32.10) were obtained. The correlation coefficient of OC with other organic carbons (WSOC and HULIS-C) was higher than that EC, which suggests that the behaviors of organic carbon fractions may be different to EC behavior. In addition, HULIS-C accounts for a significant portion of the WSOC, with an average concentration of $1.68 \pm 1.22 \mu\text{g}/\text{m}^3$.

In this study, we will understand the mass constitution of carbonaceous aerosol in PM_{2.5} and evaluate the temporal characteristics of OC, EC, WSOC and HULIS-C in PM_{2.5} at an Anmyeon-do where is GAW regional station of WMO Region II – Asia in Korea.

Derivation of A Correlation Regarding Light Absorbing Carbon based on Thermal Elemental Carbon (EC) and Equivalent Black Carbon (eBC)

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Abstract:

Thermal–optical analysis was applied to the derivation of a correlation with respect to light absorbing carbon based on the elemental carbon (EC) and the equivalent black carbon (eBC) included in PM_{2.5} at KOREATECH, Byeongcheon Campus in spring season. This study aims to find characteristics of EC derivation in OCEC analyzer. KOREATECH Byeongcheon Campus is particularly interesting because it is located just beside a factory and surrounded by rural geometrical factors such as a mountain and farmland. Both anthropogenic and natural factors affect the air quality around the campus. In the EC quantification, the carbon pyrolyzed from OC (PyC) makes the quantification difficult. The Sunset OCEC Analyzer shows information about masses of EC1, EC2, EC3 and PyC, which are fractions of EC at each temperature profiles. EC mass is calculated by the sum of EC1, EC2, EC3, EC4, EC5 and EC6 minus PyC. We observed the relationship between EC concentration and various EC fractions and concluded that EC3 was the dominant fraction for the quantification of EC in this study. The correlation between EC3 and eBC is derived for better understanding how the EC3 is connected with eBC.

Characteristics and source apportionment of ambient black carbon over an urban atmosphere in northern Southeast Asia

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Abstract:

Black carbon (BC) is a principal component of light-absorbing carbonaceous aerosols and ubiquitous in the atmosphere. BC acts as a direct climate forcing agent (IPCC, 2013) by strongly absorbing the short-wave solar as well as long-wave terrestrial radiation. Emissions of BC aerosols mainly arise from the combustion of fossil-fuel for residential cooking, industrial, and transportation uses, and open biomass-burning. For the first time, over an urban atmosphere (i.e., Chiang Mai; the largest city in northern Thailand) in northern Southeast Asia, we have determined and investigated the contribution of fossil-fuel combustion and biomass-burning components to ambient BC using multi-wavelength Aethalometer model. This study is a part of Seven South East Asian Studies (7-SEAS; <http://7-seas.gsfc.nasa.gov/>) campaign. Continuous real-time measurements of BC are carried out by using a seven wavelength (370, 470, 520, 590, 660, 880 and 950 nm) portable Aethalometer™ (AE-31, Magee Scientific, USA; <http://www.mageesci.com>) at a sampling interval of 5 min and a standard flow rate of 3 liter per minute (LPM) during March–May, 2016. The investigation of wavelength dependence revealed that BC observed at this location is generally dominated by biomass-burning emissions attributed to local agricultural residue burning during the dry season. The knowledge of BC characteristics and source origins obtained from this study will help the researchers for future atmospheric chemistry studies over the region as well as the policy makers to implement strategies concerning air-quality improvement in Chiang Mai city.

Determining Polarity Distribution of Atmospheric Water-Soluble Organic Matter by the 1-Octanol-Water Extraction Method

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Abstract:

Polarity distribution is one of the key factors to determine the influences of atmospheric water-soluble organic matter (WSOM) on hygroscopic growth and cloud condensation nuclei activation processes. Here we propose an inversion method to derive polarity distribution of WSOM based on 1-octanol-water partition coefficient (K_{ow}), which often serves as a metric of polarity and water solubility. WSOM was classified into ranges of K_{ow} by alteration of volume ratio between 1-octanol and aqueous phases. The classification was optimized by inversion and non-negative least squares algorithms. The numerical methods were evaluated by theoretical analysis and applied to aerosol particles generated by combustion of mosquito coil and Indonesian biomass. The results show that WSOM which significantly contributes to aerosol water uptake ($\log K_{ow} < 0$) only constitutes about 50% of WSOM in mosquito coil burning particles, while more than 70% of WSOM in Indonesian biomass burning particles belongs to the range. This study highlights the importance of polarity distribution when estimating the contribution of WSOM to aerosol water uptake.

Chemical characteristic, source apportionment and health implications of humic-like substance (HULISWS) in fine particulate matter (PM_{2.5}) in Hong Kong

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Abstract:

Water-soluble humic-like substances (HULISWS) are a significant component of water-soluble organic matter (WSOM) in atmospheric fine particles (PM_{2.5}). However, systemic studies regarding to the chemical characteristic, sources and redox activity of HULISWS are limited. In this study, the optical properties, mass concentration, and reactive oxygen species (ROS)-generation potential of HULISWS were investigated in PM_{2.5} samples collected in 2011-2012 in Hong Kong, and all showed higher levels on regional days than long regional transport (LRT) days and local days. Positive matrix factorization (PMF) analysis was conducted regarding to HULISWS and the dithiothreitol (DTT) activity of HULISWS. Four primary sources (biomass burning, marine vessels, industrial exhaust and vehicle emissions), and two secondary sources (secondary organic aerosol formation and secondary sulfate) were identified. Secondary processes were the major contributor to HULISWS mass concentration (54.9%), and biomass burning was the predominant donor to the DTT activity of HULISWS (62.9%) throughout the year. Specifically, unlike other sources with higher contributions on regional days than LRT and local days, marine vessels showed higher contributions to HULISWS and the DTT activity of HULISWS on local days than LRT and regional days. Regarding ROS-generation potential, HULISWS from biomass burning were the most ROS-active, followed by marine vessels, and HULISWS formed through secondary processes showed low intrinsic ROS activity.

Application of SERS on the Chemical Analysis of Nanometer Sized Aerosol Particles

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Abstract:

New Particle Formation (NPF) is an important initial step for the aerosols to take shape, and both physical and chemical understanding of the ubiquitous phenomenon is needed to better quantify the climate impacts of the atmospheric aerosols. New particles are typically few nanometers in size, which makes them particularly difficult to sample and detect, therefore posing many technical challenges even as of today. The chemical speciation of the compounds involved in the NPF is technically challenging because of the minute particle mass and short time involved in the event. There is a constant need for a more sensitive chemical analysis that can detect and resolve the evolution of the chemical compounds involved in the NPF events. In this study, we investigated the applicability of the surface enhanced Raman scattering (SERS) technique on the rapid and sensitive chemical analysis of nanometer sized aerosol particles. SERS provides a drastic enhancement of the scattering efficiency over traditional Raman spectroscopy. The novelty of the proposed technique is that the SERS substrate is directly used as the sampling substrate of the Spot Sampler (Series 110 Liquid Spot Sample, Aerosol Device Inc.). The SERS substrate requires the analyte in the form of water solution while Spot Sampler can activate nanometersized particles into liquid droplets. The condensation of water vapor by Spot Sampler ensures both inertial sampling and SERS pre-treatment simultaneously. In order to verify if the combined method using Spot Sampler and SERS substrate can be applied to chemical analysis of new particles, we collected mono-dispersed (20nm, 50nm and 100nm) ammonium sulfate and levoglucosan, directly on the SERS substrate (Ag SERStrate, Silmeco) by Spot Sampler and characterized them by using Raman spectroscopy (Nanofinder HE, Tokyo Instruments inc.). Based on the successful detection of the peaks corresponding to sulfate $\nu(\text{SO}_4^{2-})$ and organics $\nu(\text{C-H})$, the results demonstrated that our new method of combined Spot Sampler and SERS substrate has high enough sensitivity that can potentially be applied on the actual NPF events. We plan to apply this technique on the ambient samples and the results will also be presented.

Application of Electrospray Surface-Enhanced Raman Scattering (ES-SERS) Technique for the Characterization of Core-Shell Particles

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Abstract:

Surface-enhanced Raman scattering (SERS) technique has been recently applied to study the complex chemical compositions of atmospheric aerosols due to the significant enhancement of Raman intensity at sulfate, nitrate, and organic vibrational modes. Electrospray-SERS (ES-SERS) is one of the promising SERS methods which can be performed on single particle basis. Particularly, ES-SERS can provide SERS spectra highly sensitive and selective to the surface chemical compositions as opposed to normal Raman spectra, which can facilitate the characterization of internal structures within a single particle (e.g., core-shell structure). We have investigated mixed particles of polyethylene glycol (PEG) and ammonium sulfate (AS) at 1:2 mass ratio as a core-shell structured model particle (core of AS, and shell of PEG) because the mixed particles undergo liquid-liquid phase separation at 80% RH. The ES-SERS spectra obtained from the center of the phase-separated particle show that $\nu(\text{CO})$ and $\nu(\text{C-H})$ modes at 1142 cm^{-1} and 2930 cm^{-1} of PEG, respectively, are significantly enhanced, whereas these peaks are absent in the normal Raman spectra. The results confirm that the ES-SERS revealed the presence of the PEG thin layer around the AS core. We have further tested how the ES-SERS technique can be applied to quantitatively determine the particle mixing state as a function of mixing ratio between organic and inorganic substances. As a model marine aerosol, we generated internally mixed particles of oleic acid (OA) and AS with varying mixing ratios. The result shows that the peak of $\nu(\text{SO}_4^{2-})$ at 962 cm^{-1} increases with decreasing the OA concentration, implying that the OA shell becomes thinner with decreasing the OA concentration. We also examined mixed particles of succinic acid (SA) and AS. The characteristic peak of SA at 937 cm^{-1} is enhanced and the enhanced peak intensity increases with increasing the SA concentration. These results suggest that the ES-SERS spectra may provide semi-quantitative information on the organic and inorganic mixing ratios of atmospherically relevant particles.

Effect of Oligomerization Reactions of Criegee Intermediate with Organic Acid/Peroxy Radical on Secondary Organic Aerosol Formation from Isoprene Ozonolysis

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Abstract:

Secondary organic aerosols (SOA) can have significant effects on atmospheric chemistry, human health and climate forcing, but their formation mechanisms via Criegee chemistry are still poorly understood. Here we present a comprehensive theoretical investigation on the oligomerization reaction of stabilized Criegee intermediates (SCIs) with organic acid/peroxy radical by using ab initio quantum-chemical methodologies. Our results show that the ozonolysis of isoprene easily leads to a series of C3 and C4 stable CIs due to its larger exothermicity and spontaneity. The formed SCIs have two isomers: syn- and anti-, and anti- is more stable in energy than that of syn- by about 2-5 kcal·mol⁻¹. The barrier heights of oligomerization reactions are very sensitive to the size and structure of functional groups near the central carbon atom site, indicating they can be tuned by the substitutions. Reaction between SCIs and peroxy radical contributes significantly to the formation of oligomer which is the dominant component of SOA. However, the reaction between SCIs and organic acid plays an important role in aerosol nucleation in some regions where high SCI and low H₂O concentrations occur such as in terrestrial equatorial area. Such knowledge should be useful for understanding the mechanism of SOA formation from the alkenes ozonolysis and for developing atmospheric chemistry models.

Simultaneous, Sensitive and Simple Determination of Amino Acids and Amines in Continental and Marine Aerosols

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Abstract:

A method was developed for simultaneous determination of 15 amino acids and 7 alkyl amines. The method was based on the employment of high performance liquid chromatography/fluorescence detection and online derivatization with o-phthalaldehyde. The 22 derivatives were separated within 30 min including the equilibration time and detected by a fluorescence detector at an excitation wavelength of 230 nm and emission wavelength of 450 nm. The analysis procedure was satisfactorily validated by the reproducibility, recovery, linearity and detection limit of the analytes. The relative standard deviations (RSDs) of retention time and peak area for individual amino acids and alkyl amines were consistently less than 0.30% and 2.35%, respectively. Good recovery values ranging from 70% to 109% were obtained. The proposed method showed good linearity ($R^2 \geq 0.99$) in the range of 0.125-125 $\mu\text{M/L}$ for amino acids and 2.5-5000 ng/L for alkyl amines. The detection limit ranged from 0.13 pM to 0.37 pM for individual amino acids and from 0.9 ng to 7.2 ng for individual alkyl amines. The developed and validated method was successfully applied to the quantitative analysis of amino acids and alkyl amines in continental and marine aerosols in China. Among the identified organic nitrogen compounds, 7 amino acids and 6 alkyl amines were detected in every aerosol sample. Glycine was the dominant amino acid, with the average of 130.93 pmol/m^3 (accounting for 83% of the total amino acids) and 137.22 pmol/m^3 (accounting for 66% of the total amino acids) in continental and marine aerosols in China, respectively. Methylamine and ethanolamine were the most abundant alkyl amines, contributing 87% and 64% to the total alkyl amines in continental and marine aerosols in China, respectively. This work provided an accurate, sensitive and simple method to determine simultaneously amino acids and alkyl amines, and applied the proposed method to the first investigation of amino acids in Shanghai and amino acids and alkyl amines in Huaniao Island in China. The finding of considerable amino acids and alkyl amines in continental and marine aerosols may exert significant implications on nitrogen cycling and atmospheric chemistry.

The role of Fuel's Oxygen Content on Unregulated Emissions from Biodiesel Blends

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Abstract:

Diesel engines emit a number of volatile organic compounds (VOCs), which are harmful to the environment and human health. These unregulated emissions are known to depend on the type of fuel used, so this study investigated the role of biodiesel oxygen content on VOC emissions from various biodiesel blends. Experiments were conducted using a six cylinder turbocharged common rail diesel engine which was equipped with a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF). Chemical ionization mass spectrometer with H₃O⁺ as reagent ions (H₃O⁺+CIMS) was used to measure VOC emissions. 283 peaks were identified, and after background subtraction, 137 peaks were left, out of which 31 % were oxygenated, 11 % were aliphatic hydrocarbons, 8 % were sulphur containing hydrocarbons and 50 % were nitrogen (or nitrogen + oxygen) containing hydrocarbons. The hypothesis was that more oxygenated fuels will release more oxygenated compounds. The results show that PM emissions were higher in diesel fuels compared to all biodiesel blends while NO_x emissions were higher in biodiesel blends compared to diesel. Fuels with oxygen content 11.01 and above had almost twice the emissions of benzaldehyde compared to diesel. However, the emissions of formaldehyde and acetaldehyde increased with increase in fuel's oxygen content. It was also observed that though

biodiesel emitted more oxygenated compounds, however, the emission of these compounds did not necessarily increase with increase in oxygen content of the fuel. Effect of fuel's oxygen content on the emission of non-oxygenated compounds were also explored. Cyclopentene emissions increased with increasing oxygen content of the fuel while ethylene emissions showed no clear trend. Etheneamine and aniline were higher for biodiesel blends compared to pure diesel.

Observation of VOC emissions from diesel exhaust using H₃O⁺ Chemical Ionisation Mass Spectrometer (CIMS)

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Abstract:

To understand the sources of volatile organic compounds (VOCs), their chemical composition and transformations, it is important to accurately measure them. Mass spectrometry has been of immense help in the detailed measurement of these VOCs because it captures VOC variability and their chemical composition. This study aimed at using Aerodyne Chemical Ionisation Mass Spectrometer with H₃O⁺ as reagent ions (H₃O⁺CIMS) to measure VOC emissions from diesel exhaust for the first time. The sensitivity of H₃O⁺ CIMS towards some common VOCs was determined using a custom made VOC mixture. The influence of SSQ (small sequential quadrupole) and IMR (ion-molecule reaction) pressures on the intensity of reagent ions was also explored. H₃O⁺ CIMS was deployed successfully on a diesel campaign in June 2018. A total of 192 peaks were identified and 69 VOCs remained after the background had been subtracted. 15 of these VOCs were non-oxygenated hydrocarbon species, 37 were oxygenated species, 14 were nitrogen containing species and 3 were sulphur containing species. It was found that H₃O⁺ CIMS was more sensitive towards oxygenated VOCs than nonoxygenated hydrocarbons. While H₃O⁺ CIMS was found to be less sensitive towards several VOCs than other H₃O⁺ chemical ionisation mass spectrometers, it still remains a useful tool in measuring diesel VOC emissions.

Detection and Characterization of Bioaerosols in Emitted from an Urban Wastewater Treatment Plant

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Abstract:

Raw wastewater is known as a potential carrier of diverse microorganisms, which could be aerosolized during the aeration process. Wastewater treatment plant (WWTP), thus, is a potential anthropogenic emitter of airborne bioaerosols in urban area. In previous studies, bioaerosols were generally investigated and analyzed by the traditional cultivating method. The activity of emitted bioaerosols could be greatly changed during the transport in air, however, this method cannot characterize the time-series pattern of bioaerosol variation due to the limited temporal resolution. In addition, episodic concentrations of bioaerosol could be averaged as well. In this study, spatial and temporal variations of the characteristics of WWTP bioaerosols are depicted by a real-time particle spectrometry with LIF technique, i.e. UV-aerodynamic particle sizer (UV-APS). UV-APS measurements show that the peaks of fluorescent signal were located at the particle sizes around 3-4 μm . It suggests that most of fluorescence particles may be bacteria aggregates or fungal species. Additionally, the measurements were conducted at two sampling ports, 1 meter away from aeration tank and right at the tank, to study the transition of distribution pattern of bioaerosol dissemination from an urban wastewater treatment plant. The changing of fluorescence spectrums imply that dominant bacteria or fungal species among bioaerosols could be changed when emitted to the ambient environment.

Comparison of antimicrobial performance of commercial mask filters using bacterial bioaerosols

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Abstract:

Bioaerosols which are airborne particles with biological origin, have highlighted due to their negative effects on human health. Among them, airborne bacteria, fungi, and viruses are widely investigated because airborne pathogens are readily transported by ambient airflow and can cause various diseases such as infections, allergies, asthma, and chronic obstructive pulmonary disease (COPD). Against hazardous airborne particles, many people has used the face mask filter to protect their health. Commercial mask filters may satisfy their local or international evaluation standards, however, in the real-world application may not show sufficient performance against hazardous airborne particles. Besides, there were limited of information about the mask filter's filtration or antimicrobial performance against airborne microorganisms.

In this study, we evaluate the effectiveness of commercial mask filters against bioaerosols. Ten commercial masks claiming protection against PM_{2.5} (particulate matter of aerodynamic diameter of <2.5 μm) and have high market shares in Republic of Korea, were purchased from near convenience stores or pharmacies. The filtration performance of mask filters was evaluated in terms of the filtration efficiency and pressure drop. Moreover, the biological characteristics of them were investigated with *Staphylococcus epidermidis* and *Escherichia coli* bioaerosols. The filtration efficiency was measured the particle concentration of upstream and downstream of the mask filters which are installed at the head of a mannequin set in the chamber. The bacteria recovery ratio was evaluated from the measurement of bioaerosol concentrations and culturability.

The mean filtration efficiency of each mask filter was range from 78% to 99% depending on the flow rate and relative humidity (RH). As the RH increased from RH30% to RH70%, pressure drop tends to decrease in this experiment. The mean bacteria recovery ratio evaluated from test filters was range from 0.9% to 10%. Moreover, the recovery ratio of *S. epidermidis* was higher than *E. coli*'s under any condition. The face mask filter has been known as the last ditch effort for protecting our respiratory from hazardous airborne particles. However, the commercial face mask filters may not consider the biological characteristic of bioaerosols. This study provides additional information for the development of the commercial face mask filter with the antimicrobial properties and reliable guidance to users.

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Are surfaces sources or sinks of the air microbiome?

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Abstract:

As we spend more than 90% of our time in a building, there is an active interest in studying bioaerosols in indoor air as it relates closely to human health. Most of these airborne particles are generated from human activities, floor dust resuspension and fungal spore release especially in damp buildings. Occupants may experience Sick Building Syndrome (SBS) with symptoms of headache, dizziness, nausea, eye, nose or throat irritation when they inhale these bioaerosols at prolonged durations. Prussin and Marr¹ have identified eight major categories of sources of airborne microorganisms in buildings: humans, pets, plants, plumbing systems, heating ventilation and air conditioning systems (HVAC), mould, dust resuspension and outdoor environment. Whilst, Adams, et al.² found and concluded that fungi from indoor air may have originated from outdoor air from air exchanges when windows are opened. Therefore, it is critical to compare the microbial composition of outdoor air, indoor air, dust and their adjacent surfaces that are putative sources or sinks to understand source-sink relationships. To our knowledge, no studies-to-date have collected, processed and compared air and surface samples using metagenomic sequencing approach as most studies focused on sampling either indoor or outdoor environment using varying experimental protocols. Thus, it remains a challenge to draw inferences by comparing results from various studies as technical differences dominated the underlying ecological patterns.

This study aims to understand the microbial communities of air, dust and its surrounding surfaces with metagenomic shotgun sequencing in both indoor and outdoor environments. Upon completion of this study, we will be able to distinguish the sources and sinks and how various near-surfaces influence the dynamics of bioaerosols in urban tropical air.

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Taiwan and Singapore Air Microbiome Patterns in Different Season

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Abstract:

Singapore and Taiwan are approximately 3000 km apart. While Singapore is a tropical country, that is warm and humid all year long, Taiwan is a sub-tropical country with observable seasonal differences. Under general condition, due to the northeast monsoon season, the wind blows from the direction of Taiwan coming to Singapore. This study aims to explore whether bioaerosols are transported globally over a large distance by performing air sampling in locations in the two countries. One location in Singapore and three locations in Taiwan were selected for the air sampling. (Taipei, Hualien and Tainan). All air samples were collected in outdoor locations. In each location, air was sampled using 2 sets of filter-based samplers running at 300 L/min for 2 hours.

In addition to potential global transport, considering the climates of the two countries, local climactic conditions such as daily temperature or relative humidity are also expected to affect the airborne microbial community profile.

This study will be analysed by using metagenomic sequencing pipeline. Our main goals are as follows: 1) to understand the interaction and distribution of bioaerosols within the same climatic cell in different seasons; 2) to investigate how relevant are the local meteorological parameters and the air microbiome in this simultaneous sample collections project.

Mushroom genome sequencing from tropics

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Abstract:

Fungi are most abundant in air as compared to other ecosystems such as water, soil or human gut. They are major group of organisms present in tropical air microbiome. However, they are understudied because of the limited knowledge of their complete genome sequences in public databases which leads to difficult taxonomic assignment and interpretation of metagenomic reads data. The non redundant (NR) protein database at NCBI is commonly used for metagenomics read assignment. In comparison to NR database, the percentage of assigned reads improved by only 5.7% with blast search on whole genome shotgun (WGS) sequence database of fungi at NCBI which includes genomes of >3000 species. This suggests that a large number of fungi species from tropics remain unidentified from public whole genome sequence databases.

Our aim is to enrich public genome databases with genome sequences of fungi from tropical ecosystem such as Singapore to aid metagenomic studies. Among two groups of fungi i.e. Ascomycota and Basidiomycota, the later is difficult to be cultured in laboratory conditions. To get a diverse representation of their genomes, we collected fungi fruiting bodies tropical environment of Singapore. Three different nature parks in Singapore were visited for Mushroom collection during months of February, July and December to be able to sample diversity. The DNA was extracted and the fungi were assigned genus based on the Sanger sequences of ITS region or by phylogenetic clustering based on their clustering with closely known genus. Their genomes were sequenced using MiSeq illumina sequencer and the reads were assembled by Spades algorithm. The completeness of genomes was evaluated by BUSCO. The addition of these genomes significantly improved the metagenomic read assignments as compared to WGS database of NCBI.

We are working further to expand this collection representing Basidiomycota group of fungi from tropics which is under represented in genome databases. Obtaining pure cultures of mushrooms in laboratory conditions and identifying correct taxonomic names of Mushroom species are few challenges faced pertaining to not so robust fungal taxonomy.

Bioaerosol concentrations and size distributions during the autumn and winter seasons in an industrial city of central China

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Abstract:

Ambient bioaerosols in PM_{2.5} and PM₁₀ samples were measured in Huangshi City, Hubei Province of China during the autumn and winter seasons from November, 2017 to February, 2018. Both bioaerosol number concentration and size distribution (0.37 – 16 μm) were obtained by direct fluorescent staining coupled with microscopic imaging. The bioaerosol number concentrations ranged 0.05 – 3.37 # cm⁻³ for PM_{2.5} and 0.17 – 5.73 # cm⁻³ for PM₁₀, with an average of 0.90 # cm⁻³ and 1.86 # cm⁻³, respectively. Bioaerosols were dominated by fine particles of 0.37 – 2.5 μm diameter, while the proportion of submicrometer particles was more pronounced than supermicrometer particles. Based on the size distribution, bioaerosol fractions in PM_{2.5} and PM₁₀ were estimated to be 2.4±1.9% and 4.6±3.8%, respectively. Higher bioaerosol concentrations were observed in winter than autumn, and on polluted than non-polluted days. Under heavily-polluted conditions, bioaerosols in PM_{2.5} and PM₁₀ can be enriched by 6 and 3.7 times, as compared to the non-polluted levels and contribute up to 15% of PM₁₀

mass. Rainfall and snowfall appeared to lower the bioaerosol levels. As enhanced emission controls to combustion and dust sources have lowered PM concentrations, investigations of bioaerosol variability and its contributions to air pollution should be extended to other regions of China.

Tests for the Quantification of Proteins in Aerosol Particles

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Abstract:

Proteins is one of the major components in airborne biological particulate matter, and the cause of many kinds of allergies. Because of the low contents, the assays of proteins in air is very difficult and an effective method allowing the quantification of the proteins with high time resolution in aerosol particles has not been established yet. In this study, we made an effort to try to assay the proteins in aerosol particles, with laboratory experiments, and tested to real atmospheric samples. In the laboratory experiments, soil samples and rainwater samples were used. In the tests to real aerosol particles, samples collected at two altitudes, 5 m and 22 m above the ground, at a flow rate of 16.0-28.5 L min⁻¹ in time periods of 24 hour were used. When the aerosol samples were collected, the number concentration of aerosol particles in 5 size ranges were monitored, and the concentration of particles larger than 1.0 μm was used to show the variation of coarse particles and that of particles smaller than 1.0 μm to show the variation of fine particles.

Sample filters were cut into pieces, mixed in ultrapure water, and suspended by ultrasonic wave. Acetone was added into the suspensions for the extraction of proteins. The mixture was saved in -20 degree overnight and then was centrifuged. Suspensions were abandoned. Dried residues of the mixture were dissolved by ultrapure water, i.e. the solutions for protein quantification. The protein solutions, and also the controls and ultrapure water as blanks were respectively mixed with BCA reagent on microplates. A microplate reader was applied to measure the absorbance by the mixture, and protein concentration was calculated from absorbance.

Results of the repeated laboratory experiments revealed the lowest limit of the absorbance of 5.0 $\mu\text{g mL}^{-1}$, below which the results were close to the blanks. Therefore, the standard calibration curves in the experiment of real atmospheric samples with the absorbance of 5.0-100 $\mu\text{g mL}^{-1}$ were applied. Results of the assay of aerosol samples showed that the concentration of proteins in the air, from which we collected samples, was 0.20 -1.07 $\mu\text{g m}^{-3}$. Regarding the concentration of aerosol particles, these values are in the range of proteins reported in published literatures, in which samples were collected with high-volume sampler and in long-term sampling time. We found the apparent reduction of the concentration

at both 5 m and 22 m, together with the decrease of aerosol particles. On average, the air protein concentration at 5 m samples were higher than those at 22 m under stable weather conditions, while the concentration at 22 m was approximately equal or higher than that at 5 m after rain. These preliminary results indicate a possible way to quantify protein contents in aerosol particles at a timescale of 24 hours.

Building Operating Conditions are Significant Drivers of Indoor Airborne Microbiomes

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Abstract:

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Airborne bacteria are one of the major pollutants in indoor built environments. Eight representative commercial buildings across Hong Kong were analyzed in this research. We aimed to characterize and compare the outdoor and indoor airborne bacterial microbiomes, and identify the association between airborne bacterial communities and the environmental factors. A total of 189 DNA and 190 RNA air samples were collected over four seasons. Environmental factors including temperature, relative humidity and PM_{2.5} were monitored. Culture-independent next generation sequencing was employed to generate 16S rRNA sequences to analyze the characteristics of outdoor and indoor airborne bacterial microbiomes. The K-value (ratio of ventilation airflow and internal emission rate) and I/O ratio (indoor and outdoor PM_{2.5} concentrations) were used to estimate the extent of outdoor particle penetration.

Based on the Sloan neutral model, most airborne bacteria were randomly dispersed in both outdoor and indoor environments but there were significant differences between outdoor and indoor airborne bacterial microbiomes. The dominant genera such as *Propionibacterium* and *Staphylococcus* were mostly persistent at each location across seasons in the DNA and RNA samples. The taxonomic profiles of DNA and RNA samples in the outdoor and indoor environments showed minor variations at each location over seasons with a relatively small coefficient of variation.

The DNA and RNA airborne bacterial microbiomes displayed strong seasonality for both outdoor and indoor environments, but only showed a significant geographical variation in the indoor environment. Moreover, a distance-based multivariate analysis showed that the DNA and RNA airborne bacterial microbiomes were influenced by both local and dispersion effects pertinent to different geographic locations. Nonetheless, in terms of seasonality, there was only a local effect on the DNA airborne bacterial microbiomes, but there were both local and dispersion effects on the RNA airborne bacterial microbiomes.

The type of buildings (i.e., offices or malls) showed significantly different airborne bacterial microbiomes in DNA and RNA samples. Based on the results from Sourcetracker, occupants and outdoor air were the major contributors to the indoor airborne bacterial microbiomes, but the extent of contribution from each source was subjected to building operating conditions.

In summary, although the outdoor environment showed strong seasonality in both DNA and RNA samples, the RNA airborne microbiomes were more dynamic than the DNA microbiomes over seasons. The outdoor airborne bacterial microbiomes at a city-scale tended to be homogenous in different locations, but the indoor airborne bacterial microbiome could be significantly influenced by geographical locations. Since Hong Kong is one of the most densely populated cities in the world, the airborne bacterial microbiomes were composed of a large portion of human-associated bacteria. The indoor airborne bacterial microbiomes could be driven by the building operation conditions, resulting in different airborne bacterial microbiomes at different locations. The particle penetrating ability from the outdoor, different filtration efficiency for particles and bacteria, and types of internal sources (i.e., occupants and surfaces) can lead to a different airborne bacteria profile in the indoor environment.

Measurement of Airborne Influenza Viruses using an Electrostatic Particle Concentrator and Paper Sensors

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Abstract:

Air-borne influenza viruses are responsible for serious respiratory diseases and one of the biggest threats to human health because they cause high morbidity and mortality. Therefore, it is critical to evaluate the accurate concentration and pathogenicity of the bio-particles via advanced sampling and detection methods. We previously developed a personal electrostatic particle concentrator (EPC) for sampling of submicron airborne virus (MS2 and T3 phage) particles, and the collected viral concentrations were more than 10 times higher than that in the commercial impinger, BioSampler. The EPC was evaluated in this study for influenza virus aerosols which have different structural properties than the MS2 and T3 phage particles. Influenza virus aerosol was collected in 1x phosphate buffered saline solution with constant applied voltage (-5kV) and sampling flow rate (1.2 L/min). The portable Vertical flow assay (VFA) based electrochemical paper immunosensor was used for the detection of the influenza virus particles in bio-aerosols. The collection efficiency of intact influenza viruses were measured using different types of (nucleoprotein antibodies, hemagglutinin monoclonal and polyclonal antibodies) antibodies on the paper based VFA sensors with variation in collection time (10 to 60 min). The VFA based immunosensor measured 647 PFU/mL in 16 min including 10 min sampling. The concentration of virus particles increased with increase in sampling time on using nucleoprotein antibodies for detection. However, the concentration of virus particles decreased with increase in sampling time on using hemagglutinin antibodies which might be due to damage of HA protein of the virus due to sampling stress and applied voltage. The nucleoprotein based VFA sensor measured 647 PFU/mL in 16 min including 10 min sampling time and the results were independently confirmed using conventional ELISA and qPCR. Sample pad in VFA sensor acted as a filter membrane that allows the small particles (>0.45 μm) to pass through it and retains the large particles (dust particles etc.) This combination provided a reliable working system suitable for sampling and detection of bio-aerosol with high sensitivity and selectivity. This work is expected to lead to innovative, novel, inexpensive and feasible methods for biological aerosol monitoring.

Quantification of bioaerosol components in fine and coarse particulate air pollution using epifluorescence methods

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Abstract:

Despite being recognized as an important part of particulate matter (PM) air pollution and health risk, bioaerosols have not been quantified as extensively as other PM components or sources in the process of establishing PM standards and management strategies. The challenge lies partly in the diverse nature of bioaerosols, and the lack of an applicable measurement method. This study developed and evaluated a filter-based, direct-staining fluorescence microscopy (DS-FM) method that may be adapted to routine air quality monitoring for bioaerosol concentration and size distribution. Testing with bioaerosol standards made of bacterial cells and fungal spores, the method is shown to have precision, accuracy, detection limit, and dynamic range suitable for most ambient environments. DS-FM was first applied to samples from an urban desert of Las Vegas, Nevada during the spring allergy season. The bioaerosol size range was $\sim 0.37 - 16 \mu\text{m}$ and concentrations averaged $0.27 \pm 0.23 \text{ \# cm}^{-3}$ with $\sim 2/3$ and $1/3$ of bioaerosols in the fine ($\leq 2.5 \mu\text{m}$) and coarse ($> 2.5 \mu\text{m}$) mode, respectively. The bioaerosol mass, estimated from the size information and an empirical particle density, was mainly in the coarse mode (PM_{10-2.5}) and accounted for $17 \pm 11\%$ of PM₁₀ mass ($20 \pm 13\%$ of PM_{10-2.5} and $4 \pm 3\%$ of PM_{2.5}). High precipitation and wind speed appeared to elevate the bioaerosol level. These findings compare

favorably with those in the literature. Other advantages of DS-FM include low sample consumption and short turnaround time. A large amount of data can be generated for incorporating the measurement into current air quality networks. Recommendations for further validations and using the data to inform bioaerosol origin, contribution, and public health impact are discussed.

Development of an efficient viral aerosol sampling system for high flowrate

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Abstract:

Viral aerosol are highly transmissible and can result in serious health problems. Most of the current viral aerosol sampler sample at low flowrate (< 100 LPM). However, high viral aerosol flowrate samplers are needed to sample in environment with low concentration. In addition, most of the current viral aerosol sampler do not possess both high collection efficiency and viral preservation. This study aims to develop a high flow (>100 LPM) viral aerosol sampler with high collection efficiency and viral preservation. The viral aerosol collection system was designed by connecting a cooling device with the Steam Jet Aerosol Collector (SJAC). We control the cooling device and SJAC mixing reservoir temperature to improve the collection efficiency of the test aerosol. We used the All Glass Impinge 30 (AGI-30) and Biosampler for sampling MS2 bacteriophage. Bacteriophages MS2 was generated as test aerosol to 130 LPM high flow stream. When the cooling device and SJAC reservoir temperature was set to 18°C and 65°C, respectively, the system was 6 and 9 times more effective for viability preservation than the commonly used AGI-30 and Biosampler, respectively. In the future, we will test with different parameter settings and viral aerosol to verify the system's stability. Finally, this viral aerosol collection system shows as a promising prototype to evaluate the characteristics of viral aerosols in the ambient environment when sampling at high flow rate.

Fully-integrated bioaerosol monitoring system based on the continuous wet-cyclone aerosol sampling and the ATP-bioluminescence detection techniques

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Abstract:

Recently, as the incidence rate of the highly-concentrated dust in the atmosphere increases, it has become a urgent social issue with indoor air quality. The fine dust such as PM10 and PM2.5, can contain not only the hazardous heavy metal but also various microorganisms (pathogenic viruses, bacteria, and fungi). Although general airborne microorganisms, called bioaerosols, present at low concentration in the atmosphere, they can stay for a long time and can have adverse health effects on the human and environment. Therefore, it is required to develop a technique capable of effectively detecting and analyzing bioaerosols in continuous and real-time manner.

In this study, we demonstrated the fully-integrated bioaerosol monitoring system based on the continuous and enriched aerosol-into-liquid sampling and highly sensitive ATP-bioluminescence detection techniques. Collection performance tests were performed using standard-sized poly styrene latex particles and two-types of bacteria. The sampled and lysed bioaerosol liquid sample reacts with a glass fiber disc immobilized with luciferase/D-luciferin in a few seconds, and the emitted luminescence light was measured continuously using a PMT. In this system, the particle collection efficiency is >99% on 1- μm particle, and the detection limit of the bioluminescence is ~ 0.1 fmol of ATP. This study demonstrated the possibility of a continuous and real-time bioaerosol monitoring system by applying it to various real environments.

This research was supported by the KIST Institutional Program and, in part, by the Ministry of Environment, Republic of Korea, via the Public Technology Program Based on Environmental Policy (2016000160008).

Large scale isolation of microorganisms from tropical air in Singapore

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Abstract:

To reveal microbiome and their ecosystem in urban outdoor air of Singapore, we have two different approaches, metagenomics for non-cultured samples and deep-coverage whole-genome sequencing for cultured samples.

For generating cultured samples, we collected airborne microbes using Spin Air (IUL, Spain) at 100 L/min for 20 seconds. To obtain maximum diversity of isolate collection, we used numerous types of nutrient agar plate, and the plates were incubated at various conditions (temperature and oxygen levels). Forming colonies were picked up and streaked onto fresh agar plates and incubated. The isolation process was repeated at least three times and/or until isolates are morphologically singular.

We performed 6 sampling events over 3 years in different monsoon seasons and have collected ~1000 isolates biobanked. Sanger sequencing on the marker gene (16S rRNA gene and ITS) was applied to examine the identify of each isolate and has processed to ~70% of the collection. The major populations in the collection were *Bacillus*, *Cellulosimicrobium*, and *Pantoea* of bacteria and *Fusarium*, *Aspergillus* and *Penicillium* of fungi.

Importantly, each of 100 bacterial and fungal isolates have been sequenced to their whole genome on short and long read next generation sequencing technologies to construct platinum quality of de-novo assembly genome data. The datasets will be included in the database of tropical airborne microbiome.

Evaluation of the influence of forest fires and fungal spores on resuspension of radiocesium from a forested area using terrestrial biomarkers

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Abstract:

The Great East Japan Earthquake led the Fukushima Daiichi Nuclear Power Plant (FDNPP) accident in March 2011 and released a large number of radionuclides into the atmosphere. Most of them were captured in the forest canopies because 71 % of Fukushima Prefecture is covered with forest. During our survey periods from 2012 to 2015, the activity concentrations of ^{137}Cs in the ambient air ranged from approximately 10–5 to 10–2 Bq per m^3 and were higher in the warm season than in the cold season at Namie, a heavily contaminated forest area of Fukushima. That suggests the resuspension of ^{137}Cs from the forest in warm season from spring to summer, but its mechanism has been poorly understood. There are possibilities of the emission of fungal spore, pollen, and debris of plant wax by the weathering in this season, which are called bioaerosols. There is another possibility of forest fire because it occurs frequently in Fukushima Prefecture in spring. Previous study revealed that ^{137}Cs with a boiling point of about 670°C is re-suspended by forest fires and could be even long-range transported by the whole boreal burning activity. The objectives of this study are to make clear the concentrations of biomass tracers of fungal spore, pollen, and debris of plant wax, and forest fire at Namie and to elucidate the relationship between them and ^{137}Cs concentration.

We collected particulate matters on quartz-fiber filter by high-volume air samplers at Namie High School which is located 30 km northwest from FDNPP. We analyzed levoglucosan as a biomass burning tracer and n-alkane (n=27, 29, 31) as a tracer of plant wax by GC-MS. Phthalic acid and water soluble organic compounds (WSOC) were also measured as indicators of the formation of secondary organic aerosol by

TOC analyzer. Sugar alcohols such as mannitol and arabitol as biomarkers of fungal spore were also measured with levoglucosan by UPLC-MS/MS.

The concentration of levoglucosan reached 30 ng/m³ at the maximum during the period from 2013 to 2016 and was higher in spring. Levoglucosan concentration significantly increased in most cases during the occurrence of forest fires, but ¹³⁷Cs concentration was not always high even though air mass came from the direction of forest fire region. There was no good correlation between phthalic acid and ¹³⁷Cs in this study, but n-alkane sometimes had similar behavior with ¹³⁷Cs in 2016. There was a large forest fire in Mt. Juman-yama, which continued for 10 days from April 29 to May 10 in 2017 and about 75 ha of the forest were destroyed. There were poor correlations between them although our sampling site was in the vicinity of the mountain. The increase of ¹³⁷Cs concentration was observed after the fire extinguished. The impact of forest fire on the resuspension of ¹³⁷Cs from the forest has not been elucidated yet, so further study is needed. We will present the behavior of fungal spore tracers in poster session.

Inactivation of airborne bacteria using vacuum ultraviolet light

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Abstract:

Airborne bacteria have affected human health significantly, which has attracted much attention recently, and many techniques have been developed for inactivating them. Among the techniques, ultraviolet photocatalytic oxidation (UV PCO) is known as a high-level oxidation treatment because it is more efficient than conventional methods, such as filtration & heat treatment, and is easier to maintain and manage. The most commonly used UV light sources in the UV PCO systems are UVC and UVA, which have wavelengths of 254 nm and 365 nm respectively. Although these UV light sources are known to have high efficiency for inactivating airborne bacteria, they show low photocatalytic efficiency in a short exposure time. Previously, we presented vacuum ultraviolet (VUV) light with photocatalysis for inactivating airborne MS2 phages, and it showed that the VUV PCO system efficiently (overall efficiency: ~90%) inactivated the airborne viruses in a very short reaction time (0.009 s and 33 L/min). In this study, we extended the study to inactivate several airborne bacteria: *Pseudomonas fluorescens*, *Micrococcus luteus*, *Mycobacterium parafortuitum*, and *Escherichia coli* K-12 by irradiating VUV light onto 2mm pleated Pd-TiO₂ photocatalyst. When VUV was applied to airborne *Pseudomonas fluorescens* for 0.009 second, more than 90% inactivation efficiency was observed, and overall ozone degradation efficiency was 75% or more. The system is expected to be a good alternative to existing UV-based air purifiers.

The Microbiome of Settling Dust from Childcare Centres in Singapore

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Abstract:

The air conditioning system plays an important role in reducing exposure to particulate matters from indoor and outdoor sources. There are three common types of ventilation systems in Singapore: centralised system, split unit system and natural ventilation. Our study focused on childcare centres with different ventilation systems that are located within busy residential or industrial areas. There is a general interest from the public to find out the extent to which children are exposed to potential air quality problems since they spend most of their time in the centres. Due to noise and space constraints, we used passive settling dust sampler in this study. Past studies^{1,2} have indicated the relevance of studying dust microbiome to understand the microbiome of settling and resuspended airborne particles. Metagenomic shotgun sequencing was used to characterise settling dust samples collected from childcare centres in a tropical climate. We aim to compare DNA yield and microbial community from indoor/outdoor sites and from different ventilation types.

The sampling was performed by hanging sterile petri dishes (150 x 15 mm, polystyrene, Falcon, USA) on fixtures such as lights or window frames within the indoor premise and outdoor locations (8 dishes each) in the selected centres. After 4-week of passive dust collection, the dishes were transported back to the lab and stored at -20°C. Dusts from each petri dish were first suspended in 2 mL of PW1 (lysis buffer, Qiagen, USA) + 0.1% Triton X-100 with a cell scrapper. The dust suspension (1 mL each) was transferred into two bead tubes (Qiagen, USA), and DNA was extracted with DNeasy PowerWater kit according to protocol by Luhung et al. (2015)³. DNA was sequenced with shotgun sequencing approach (Illumina HiSeq) and RAPSearch2 was employed to analyse the raw sequence data. MEGAN software was then used to visualize the metagenomes.

The results reveal that fungi were more abundant outdoor. Whilst, bacteria, especially human associated bacteria of the family Staphylococcaceae and Micrococcaceae were more abundant indoor. The naturally ventilated centres also showed the highest similarity in dust microbial community between indoor and outdoor as compared to the other samples. Our findings highlight the limitation of passive sampling when quantitative analysis is needed as it tends to only collect settling particles. Nonetheless, our study was able to show the difference in microbial communities among the samples which highlights the role of each unique ventilation system in filtering particulate matters from both indoor and outdoor sources.

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Mold Growth in a Tropical Office Building in Singapore

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Abstract:

This study focuses on systematic comparison between two office spaces in the same building. Office 1 is a well-maintained office, served by an air handling unit (AHU) with a high rated filter that performed regularly. Office 2 is a similar office space with a low rated filter that ran intermittently to save energy. Within months, mold growth was observed in various surfaces of the Office. It was soon followed by foul odour and reports of occupants falling sick.

This study aims to investigate the two offices by conducting a series of surface and air sampling in the two locations. In addition to indoor samplings, ventilation system filter collection, outdoor reference sampling, real-time temperature/RH sensors and air exchange rate estimation were also conducted. Utilizing DNA-based qPCR and metagenomic sequencing approach, we look to understand how building operational decisions could impact the indoor environmental quality (IEQ) in a tropical built-environment setting. We are also ultimately looking to explore both prevention and remediation solutions by evaluating how they would directly impact the IEQ.

Surface, air and ventilation system samples will be analysed using an in-silico tool, SourceTracker2, to predict the relative contributions of each sample as sources to the nearby office air with Bayesian probability methods. One of the earliest attempts of such comparison analysis was conducted by Bouillard et al. (2005), which utilized culture and microscopy-based methods to analyze dust, air and surface samples collected from various environments. Understanding, eliminating and preventing recurring fungal growth at the identified sources not only improve the office air quality but also the occupants' health and work performance.

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Factors for Particle Number Variation at Fukuoka Japan in Winter Period

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Abstract:

Particulate matter (PM) is one of the important constituents in air quality. Fukuoka city is located in the western area of Japan and its population is about 1.5 million, therefore, both transboundary and local air pollutions are important.

Particles under 100nm of its diameter is called Ultra Fine Particle (UFP). At the road side, UFP number concentration (NC) is high, while at the residence area, which is about a few hundred meter away from road side, UFP-NC is low.

We measured UFP at the one of the laboratories in Fukuoka Univ., located about a few hundred meter away from road side. NC with the particle diameter of about 25nm (NC25) increased under the calm condition in the morning with CO increase. While NC25 was low under the strong wind with CO decrease. NC25 seems to increase under the low wind speed condition due to the local emission in Fukuoka.

UFP (NC25) was high at the residence area located away from the roadside, which is different from the previous observation in Kawasaki and Saitama and is similar to Nagoya, Japan. We plan to investigate more with solar radiation and NO_x data.

Sources of polycyclic aromatic hydrocarbons in PM_{2.5} in urban Shanghai, China

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Abstract:

Providing quantitative information on the sources of PM_{2.5}-bound polycyclic aromatic hydrocarbons (PAHs) in urban region is significantly important to establish effective abatement strategies for air pollution in the megacity. In this study, based on a year data set from October 2011 to August 2012, the sources of PM_{2.5}-bound 16 USEPA priority PAHs (16 PAHs) in an urban site of Shanghai, a megacity in China, were apportioned by positive matrix factorization (PMF) modeling. The average concentrations (in ng/m³) of 16 PAHs in PM_{2.5} in fall, winter, spring and summer were 20.5 ± 18.2 , 27.2 ± 24.0 , 13.7 ± 7.7 and 6.4 ± 8.1 , respectively, and with an annual average of 16.9 ± 9.0 . The source apportionment by PMF indicated that the coal burning (30.5%) and gasoline engine emission (29.0%) were the two major sources of PAHs in the PM_{2.5} in Shanghai, followed by diesel engine emission (17.5%), air-surface exchange (11.9%) and biomass burning (11.1%). The highest source contributor for PAHs in fall and winter was gasoline engine emission (36.7%) and coal burning (41.9%), respectively; while in spring and summer, it was the diesel engine emission that contributed the most (52.1% and 43.5%, respectively). It was suggested that there was a higher contribution of PAHs from the engine emission in 2011-2012 compared with that in 2002-2003. The major sources apportioned by PMF complemented well with that of using diagnostic ratios, suggesting a convincing identification of sources for the PM_{2.5}-bound 16 PAHs in a megacity.

Chemical speciation of trace metals in urban particulate and its health risk

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Abstract:

Atmospheric particulate matter is the general term for all kinds of solid and liquid particulate matter in the atmosphere. The chemical composition of atmospheric particulate includes inorganic matter, organic matter and living matter. Trace metals are important components of the inorganic matter. Chemical speciation of the trace metals is the actual way in which a trace metal element combined state in the particulate matter. The activity, migration pathways, bioavailability and toxicity of heavy metals depend on the form of the elements rather than the total amount.

We collected the SPM at three sites in Japan, i.e. at the roof top of eighteen-storied building (64 m) in Nishi-Waseda campus, Waseda University (Shinjuku, Tokyo) as an urban background site, at Meji street near the campus as a roadside site, and at the southern foot of Mt. Fuji (1300 m a.s.l.) as a mountain site. Mt. Fuji is located 100 km west from Tokyo. The high-volume sampler was used to collect the atmospheric particulate matter at a flow rate of 1000 L/min onto a quartz filter membrane (8 × 10 inch²). In this study, the improved Tessier's method (Fernandez et al., 2002) is modified and applied to the analysis of trace metal speciation in SPM. We divided the trace metals in the atmospheric particles into four fractions: Fraction 1 (F1, soluble and exchangeable), Fraction 2 (F2, carbonates and reducible), Fraction 3 (F3, organic and oxidizable), and Fraction 4 (F4, residual, insoluble fraction). We replaced the shaker agitation in the previous method with ultrasonic extraction and used the microwave digestion to eliminate the residue. Twelve trace metals (Al, V, Cr, Mn, Fe, Ni, Cu, Zn, Cd, Pb, Se, and As) in four fractions were analyzed by ICP-MS (Agilent 7700x). We here report the yearly, seasonal, and diurnal change of trace metals in SPM in urban site and their characteristics compared with those in the mountain site.

Total concentration of metals in SPM was 4.34 µg/m³ at the road side, 4.66 µg/m³ at the urban background site, 3.65 µg/m³ at the mountain site on the annual average in 2016, respectively. Major trace metals were Al, Fe, and Zn at three sites. The concentration of As, Se, Pb, and Cd was higher at the road side than that at the urban background site, indicating these trace metals were emitted from automobile. Zn, As, and Cd were mainly in F1 through a year while Al, Fe, and Se were mainly in F3 and F4 in the urban site. The bioavailability sequence of trace metals is F1 > F2 > F3 > F4, suggesting that Zn, As, and Cd were highly bioavailable and potentially toxic. We will discuss the average daily dose, hazard quotient (HQ) for no-carcinogenic trace metals, i.e. Cu, V, Zn, Pb, Zn, Se, and the incremental lifetime

cancer risk (ILCR) for carcinogenic trace metals, i.e. Cd, Cr, Ni, and As based on our results. Furthermore, we will also discuss the relationship between each fraction of trace metals and oxidative stress measured by DTT assay.

Characterization of daily PM₁ at the top of Mt.Fuji in summer 2018.

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Abstract:

In order to evaluate aerosol pollution in Kanto area in Japan and influence of long-range transportation, we conducted a sampling campaign at Kazo, Tokyo, the top of Mt.Fuji, Mt.Halla of Jeju Island and Shanghai during a month. We are focusing on submicron particles, PM₁ since it is suitable to evaluate aerosol emitted from anthropogenic emission sources. PM₁ at the top of Mt.Fuji was collected using a PM_{2.5} sequential sampler installed at the first building of meteorological station, attached PM₁ classifier instead of PM_{2.5} impactor. Inorganic ions and elements were measured and compared with those at the other sites focusing on some elements and its ratio.

Peat-forest Smoke in Maritime Continent: Classification of Transboundary Impacts on Receptor Urban PM_{2.5} and Burning Conditions

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Abstract:

Systematic classification of impacts of transboundary pollution on receptor air quality is important for objective assessment and needed to strategize rapid response to protect and communicate with the public. Nevertheless, it is challenging in an ambient environment comprising complex and changeable airborne components. Among the published literature, there can be arbitrary definition of “haze” or “smoke” samples (and periods) to compare with “non-haze” or “non-smoke” references that are vaguely determined or less than representative. Hence, this study investigates ~200 urban (daily 24-hour) PM_{2.5} samples collected through multiple years during 2012–2015 to classify how cross-border peat-forest smoke affects urban fine particulates. By analyzing more than 10 chemical components of PM_{2.5}, and coupling with backward trajectories of air mass, meteorological conditions and information available at public domain, PM_{2.5} samples are classified as smoke dominant (SD) or non-smoke dominant (NSD) depending on the contribution of transboundary biomass burning (BB) smoke relative to local emissions, with the former representing a dominance of transboundary BB smoke at the receptor site. Due to little BB at the receptor site, Levoglucosan concentration serves as a good proxy for classification; values of $\geq 0.2 \mu\text{g}/\text{m}^3$ warrant the transboundary BB smoke as the dominant factor affecting urban receptor environment, and thus yielding SD PM_{2.5}. On the other hand, a Levoglucosan concentration of $< 0.1 \mu\text{g}/\text{m}^3$ shows that BB smoke, if present, exerts little effects on the receptor urban environment, qualifying PM_{2.5} as NSD. PM_{2.5} comprising a Levoglucosan concentration between 0.2

and $0.1 \mu\text{g}/\text{m}^3$ often results from the urban environment affected by complicated and variable factors, such as intermittent rainfalls, changing peat-forest (PF) smoke emission strength, wind direction, etc., and requires additional examination. For fast classification (on hourly basis) to enable more rapid response, total organic carbon (OC) serves as an alternative indicator for it shows a satisfactory temporal correlation with Levoglucosan concentration in a fashion of 2nd order polynomial ($r=0.94$). Applying a threshold OC concentration of $6.0 \mu\text{g}/\text{m}^3$ can classify receptor PM_{2.5} as the SD with a >90% accuracy. Based on the established classification, the concentration ratios of char-elemental carbon (char-EC) to soot-EC for SD PM_{2.5} show additional insights that the PF smoke reaching the urban receptor site in 2012 was dominantly emitted from smoldering whereas in 2013 and 2015 from more flaming fires. The temporal trend of the char-EC to soot-EC ratio in 2012 increased from initially <1.6 up to 35. This indicates succession changes in PF burning conditions of smoke origins, switching from initially less smoldering (or more flaming of on-ground materials) to substantially dominant smoldering. Unlike the PF smoke impacts in 2012, the SD PM_{2.5} in 2013 and 2015 showed relatively unvaried ratios below 1.8 and 0.8, respectively. This suggests that both the PF smoke, causing a short yet acute episode in 2013 and the longest smoke episode in the urban receptor in 2015 resulted from less changeable apportion of smoldering and flaming emissions.

A comprehensive characterization of amines on PM2.5 aerosols in Hong Kong

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Abstract:

Atmospheric amines play an important role in new particle formation and the production of secondary organic aerosol. However, current knowledge about amines, such as their concentrations and fates in the atmosphere, are still very limited. In this study, a comprehensive characterization of amines on PM2.5 samples collected in Hong Kong during 2016-2017 was conducted. Fifteen amines, including six aliphatic amines and nine aromatic amines, were detected by GC-MS with prior derivatization by isobutyl chloroformate (IBCF). The average total concentration of 15 amines was 30.16 ± 16.49 ng m⁻³. A significant seasonal variation was observed, and the total concentration of amines showed the highest value (55.15 ± 14.63 ng m⁻³) in summer among all seasons. Of the identified 15 amines, methylamine, dimethylamine, and diethylamine were the most abundant (3.54 ± 2.71 ng m⁻³, 7.50 ± 5.62 ng m⁻³ and 9.55 ± 5.35 ng m⁻³, respectively), accounting for 67% of total amines. Higher concentration of methylamine was observed on the days mainly influenced by regional pollution than days influenced by long regional transport and local emissions. Most amines exhibited higher concentrations on regional days. However, for diethylamine, its concentration almost doubled on local days than that on regional days, indicating it may originate from marine sources. Dipropylamine and several aromatic amines (aniline, piperzine, o-toluidine, benzylamine, n-methylaniline) showed constant ambient levels under different meteorological conditions, suggesting that they are from local sources, e.g. vehicle source.

Key words: Amines, PM2.5, Hong Kong, seasonal variation, meteorological condition

Effect of Atmosphere Particle Properties to Visibility

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Abstract:

Visibility degradation is one of the most noticed impacts of particle concentrations in the ambient air. The impairment of visibility can be attributed to the scattering and absorption of visible light by suspended particles. However, different components of particle might bring the contrasting effect of extinction efficiency. Thus, the purpose of this study tries to find the correlation between visibility and physical-chemical composition of PM_{2.5}. There were four seasons sampling from November 2017 to July 2018 in Cianjin (urban) and Ciaotou (suburban), southern Taiwan. Integrating Nephelometer and AE33 were used to measure the aerosol optical properties, which were then compared with the calculated values based upon the measurements of aerosol concentration, size distribution and chemical composition (NH₄NO₃, (NH₄)₂SO₄, EC and TOC). The result indicated that the particles usually grew into larger size range as the relative humidity was above 80% in fall and summer. In addition, particle concentration and extinction coefficient in fall were higher than that in summer. The chemical composition concentration of particle such as (NH₄)₂SO₄ and NH₄NO₃ in Cianjin was higher than in Ciaotou. The size range distributed in the visible region between 0.4 μm and 0.7 μm, thus the visibility in Cianjin was lower than in Ciaotou. The correlation between PM_{2.5} properties and visibility found in this study may be useful in further visibility related monitoring planning and strategy setting to improve the visual air quality.

Analysis on Air Pollutants Reduction Potentials of Ceramics Industry in Tangshan

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Abstract:

Tangshan in Hebei Province is one of the important cradles of ceramics industry in China. As the traditional and characteristic industry of Tangshan, ceramic industry has the characteristics of large number of enterprises, low concentration and diversified kilns. The reduction of atmospheric pollutants in the ceramic industry is one of the urgent problems to be solved in Tangshan. Based on the analysis of current emission status and investigation of central and local ceramics industry policies, this research analyzes the emission reduction potential of SO₂, NO_x, PM_{2.5} and VOCs in the ceramic industry of Tangshan during the 13th Five -Year Plan period (2016-2020). Using the scenario analysis method, the research designed 3 scenarios to estimate the reduction potential according to policies control and feasible technology. Suggestions on emission reduction measures are proposed on the local and provincial levels. The results show that the maximum emission reduction of SO₂, NO_x, PM_{2.5} and VOCs from ceramics industry were 7.85×10²t, 1.38×10³t, 3.42×10²t, 1.67×10⁴t in 2020, respectively, 94.7%, 73.0%, 98.2% and 73.7% less than which in 2016 due to implementation of major emission control measures including the transformation and upgrading plan of ceramic industrial parks, eliminating backward production capacity and installing environmental protection facilities.

Chemical Analysis and DTT Assay of Powder Form of Atmospheric Particulate Matter Collected by Cyclone in India and Japan

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Abstract:

Compared with the coarse particulate matter, fine particulate matter (<2.5 μm in aerodynamic diameter; PM_{2.5}) has characteristics of smaller particle size, easier to inhale in the respiratory system, so it has great influence on human health and atmospheric environment quality. The influence of particles on human health ranges from minor upper respiratory irritation to chronic respiratory and heart disease to lung cancer. Short- and long-term exposures have also been linked with premature mortality and reduced life expectancy. In addition, numerous epidemiological studies have shown adverse health effects by fine and coarse aerosol particles such as PM_{2.5} and yellow sand. For this reason, aerosol cell exposure studies are currently required. However, the filter collection, which is a conventional sampling method, cannot collect a sufficient amount of atmospheric particles to carry out toxicity assays using cells. When atmospheric particles collected by filter method were used in the cell exposure experiment, influence of contaminants derived from the filter material cannot be avoided. So we propose a new type of high-volume sampler using an impactor and a cyclone, which can also avoid the effect of filter material and the clogging of the filter. It has two parts to collect samples, cyclone and back-up filter. This sampler can collect above 100 mg of particles in a few days. The 50% cut-points of the cyclone for ambient aerosols at 1,200 L/min of air flow was 0.3 μm .

Oxidative stress is considered to be an important potential mechanism exposing under PM that may cause unhealthy effects. Oxidative stress occurs, when the production of reactive oxygen species (ROS) or free radicals exceeds the available antioxidant defenses. Oxidative potential (OP), defined as an ability of PM to oxidize target molecules, has been proposed to be closely related to the biological response of PM exposure. Thus, the OP may be more informative than PM mass itself in terms of aerosol toxicity.

With the development of global industrialization and urbanization, the problem of PM_{2.5} in the atmospheric environment has become increasingly serious. India, as an Asian country with rapid

economic development, have a typical representation of air pollution. The annual mean concentrations of PM_{2.5} was found to be about 160 µg/m³ in 2013.

In this study, aerosol particle samples have been collected by the cyclone sampler at National Physical Laboratory, Delhi, India and Keio University, Yokohama, Japan. Chemical analysis (the concentration of metal elements, water-soluble ions) of the collected particles has been carried out followed by DTT (Dithiothreitol) assay to measure the oxidative potential which is an indicator of the in-vivo oxidative stress of aerosol particles.

Comparison of chemical characteristics of PM_{2.5} between Beijing, China and Gwangju, Korea in 2018 winter

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Abstract:

Particulate matter less than 2.5 μm (PM_{2.5}) in the ambient atmosphere is of great interest due to its effects on human health and climate change via radiation balance and cloud formation. Intensive measurements of PM_{2.5} were simultaneously conducted at a suburban site in Beijing (Changping), China, a remote site in Tuoji Island, China and an urban site in Gwangju, Korea during the winter of 2018 (1/3/2018-2/2/2018). Filter samples were collected daily for the analyses of ions, organic carbon (OC), elemental carbon (EC) and elements as well as organic compounds and Pb isotopes. In addition, online measurements of number size distribution and black carbon (BC) concentration by using the scanning mobility particle sizer (SMPS) and aethalometer, respectively, were carried out in Gwangju. The average mass concentration of PM_{2.5} at Beijing was much higher than those at other sites; Beijing (62.45 ± 34.09

$\mu\text{g}/\text{m}^3$), Tuoji Island ($25.55 \pm 21.84 \mu\text{g}/\text{m}^3$), and Gwangju ($26.77 \pm 13.91 \mu\text{g}/\text{m}^3$). The PM_{2.5} in Beijing was dominated by elements (35.3%), followed by carbonaceous species (OC and EC) (27.9%) and ions (19.6%). In the case of the PM_{2.5} at Tuoji Island and Gwangju, ionic components (Tuoji Island: 60.0%, Gwangju: 48.8%) has the highest fractions, followed by carbonaceous species (Tuoji Island: 22.1%, Gwangju: 19.9%) and elements (Tuoji Island: 11.0%, Gwangju: 10.3%). Significant differences of fraction in chemical components were also found among sites. The fractions of Ca⁺, Cl⁻, elemental Si, elemental Ca, and OC were much higher at Beijing than those at Gwangju. The NO₃⁻ and elemental S fractions significantly increased at Gwangju and Tuoji Island. Further investigation of major sources for PM_{2.5} at three sites is being in progress.

Re-examining EC-tracer Methods to Determine Primary OC and Secondary OC in Urban PM_{2.5}

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Abstract:

Organic aerosols have been responsible for a dominant component of PM_{2.5} at various locations. Since accurately quantified primary organic carbon (POC) and secondary OC (SOC) can carry substantial implications on control priorities and potential health impacts, independent methods are needed to assess the resultant values. To estimate POC and SOC, the most commonly used EC-tracer methods determine the primary OC-to-EC ratio (OC/EC) of a specific set of data in three ways, by adopting (1) the lowest OC/EC value, (2) the slope of OC-EC correlation, and (3) the regression slope of high edged OC-EC ratios (more than 2 standard deviation from the mean OC-EC ratio). An independent method estimates POC and SOC based on carbons apportioned in individual primary and secondary sources via applying statistical models (e.g. positive matrix factorization). However, complexities arise in such approaches as assigned primary emission sources can often be mixed with other less dominant emission origins and processes (e.g. photooxidation) and also contain SOC. Hence, assuming carbon in a yielded factor are all attributed to the assigned dominant source nature can bias resultant amounts of POC vs. SOC. To investigate potential discrepancy among all methods, this study estimates diurnal and nocturnal variations in POC and SOC based on hourly data of OC, EC and ionic species of PM_{2.5}, coupled with NO_x and CO concentrations in an urban atmosphere. We also analyse the proportion of POC and SOC of each identified source yielding from PMF applications, to compare with values resulting from attributing carbonaceous materials in a specific factor according to the dominant source nature.

Our preliminary results show that the diurnal and nocturnal SOC is responsible for ~20% and 18% of total OC, respectively. Applying the three EC-tracer methods to individual sources results in a daytime SOC contribution of 36–62% of total OC, and nocturnal SOC of 23–60%. Applying the primary OC-EC ratio based on the high-edge method or the minimal OC/EC results in higher SOC concentrations by \geq 25% compared to adopting the slope of OC-EC correlation. Nevertheless, any of the three EC-tracer methods shows an SOC concentration higher than the values approximated based on the dominant source nature of individual PMF factors by at least 33%. This suggests that further examination is required to enhance consistency and accuracy (or minimize underestimation) of SOC if one estimates POC and SOC of PM_{2.5} by applying apportionment via PMF. More detailed analyses will be provided during presentation.

Study for Sampling and Analysis of Ambient Acid Gases considered as Long-Range Transported Air Pollution in Korea

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Abstract:

In Korea, the Ministry of Environment has designated 23 types of air pollutants as long-range transported air pollutants which include PM_{2.5}/PM₁₀ and some of hazardous air pollutants (HAPS) such as Chloroform, Benzene and Formaldehyde. These 23 long-range transported air pollutants are divided into two types: inorganic and organic compounds. Inorganic compounds comprise 11 components including strong acid gases such as hydrogen chloride (HCl), hydrogen fluoride (HF) and hydrogen cyanide(HCN).

The sampling and analytical method for the strong acid gases are already established for the process test method of emission gas, but there are no proposed sampling and analytical methods in ambient air. Therefore, in this study, the proper sampling and analytical method is proposed for these acid gases to be monitoring continuously of these pollutants as long range transported air pollutants. The previous studies suggested three different methods for the sampling methods of acid gases in the ambient air, such as the filter impregnation method, sampling by coated denuder, and impinger method.

In this study, sampling was carried out using the annular denuder system and then Ion Chromatography(IC) with conductivity detector was applied as an analytical method because it could analyze several acid gases simultaneously. The calibration of the standards for HCl and HF showed good linearity as the the r-square value reached 0.999. We will examine MDL values of these two gaese in IC and also, compare these results with that measured by real-time measurements instrument at Intensive

Air Quality Monitoring Station locate at Seoul. In addition, we will compare the collection efficiency of two sampling methods which are denuder method and filter impregnation, respectively. Finally, the variation of HCl and HF concentrations in the atmosphere will be discussed.

Chemical characteristic and source apportionment of PM_{2.5} in Anshan, China

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Abstract:

In order to understand the characteristic of airborne particles and identify the sources of PM_{2.5} in Anshan, PM_{2.5} samples were collected at six urban sites in four segregate 14-day periods from July 2014 to April 2015 and were analyzed for chemical compounds including water soluble inorganic ions (WSIN), trace elements, carbonaceous species (OC/EC), polycyclic aromatic hydrocarbons (PAHs). Various approaches including chemical mass balance (CMB) model, cluster analysis of back trajectories, potential source contribution function (PSCF) model and concentration-weighted trajectory (CWT) model were used for indentifying source, apportioning contributions from each source and tracking potential areas of sources.

Temporal and spatial variations of PM_{2.5} and source inferences in western plain area of Taiwan

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Abstract:

This project analyzed hourly data of PM_{2.5} and gas pollutants monitored at all the stations of Taiwan Environmental Protection Administration located in the northern, central, and southern air quality districts (AQDs) in Taiwan from January 2006 to December 2017. Among various stations, determination coefficient (R^2) of linear regression analysis and the coefficient of divergence were applied to the selection of the representative stations for the following discussion.

In general, local pollution sources influenced more than distant sources to the northern AQD. To reduce PM_{2.5} concentration, controlling the mobile sources is necessary in Taipei metropolis especially in the city center. The pollutants in the central AQD tended to transport from the Taichung City to the mountains. For the southern AQD, the land-sea breeze might have transported PM_{2.5} concentrations from high in the coastal to low in the inland areas. Consequently, stationary sources and the ship emissions in the harbor area accounted for the pollution. Among three AQDs, the southern AQD reduced most in amount and time variation rates of PM_{2.5}. However, the yearly average of the PM_{2.5} concentration in the southern AQD is still the highest. Transboundary long-range transport has been a concern for pollution contribution in the northern Taiwan. The contributions of long-range transport events in contrast to non-events at the Wang-Li and Kee-Lung stations showed that the PM_{2.5} and O₃ daily averages increased roughly 120% and 25%, respectively, in 2017. For the influence of the second largest world coal-fired power plant in the central AQD, the analysis of PM_{2.5} and SO₂ cannot support the contribution of the Taichung Power Plant to the local areas, but cannot wipe out the possibility of pollution transport to the farther areas, either.

Pulmonary bioaccessibility assessments of trace metals in PM_{2.5} and associated health risks: method comparisons

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Abstract:

Air pollution is a serious environmental issue threatening human health, especially the fine particulate matters (PM_{2.5}) in cities of China. As an important aerosol component, PM_{2.5} bound trace metals pose significant health risks through inhalation, which is determined by the bioaccessible fractions dissolved in lung. To accurately assess the inhalation risks of airborne metals, several in vitro physiologically based extraction tests (PBET) simulating human lung fluids were conducted to evaluate the pulmonary bioaccessibility of trace metals in PM_{2.5} from different areas (urban, industrial, suburban, rural) of Nanjing, eastern China. The standardized and systematic bioaccessibility methods for inhalable metals are needed for future health risk assessments of aerosol pollution.

Investigation of Contributing Factors for Nano- and Micro-particulate Concentrations in Urban Street Market Area

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Shih-Chun Candice Lung, Academia Sinica

Abstract:

Most people in Asian metropolitan areas live in communities with a mixture of homes, shops, restaurants, street markets, temples, and small factories, where they are closely linked with residents' daily lives. Since this kind of mixed community (as opposed to truly residential communities in western countries) has various sources emitting pollutants in the immediate living environments, high spatial variations in pollutant levels could be found in the same neighborhood, even within short distances. Among the various microenvironments, street market is an environment with clustered stores and street vendors, as well as long-term and regular business activities, which in term could deteriorate local air quality. The objectives of the study were to investigate the variability of nano- and micro-sized particulate concentrations and the factors affecting particulate air quality in an urban street market in Taichung metropolitan area.

In the current study, levels of particles were monitored in the street market area and a tourist's breathing zone. Continuous multi-sized particulate matters (PM), ultrafine particle (UFP) and polycyclic aromatic hydrocarbons levels were measured using a light-scattering monitor/sequential mobility particle sizer (series 1.108 and SMPS+C, Grimm), a condensation particle counter (model 3007, TSI), and a photoelectric aerosol sensor (PAS 2000CE, EcoChem Analytics), respectively. Results showed that mean daytime PM₁, PM_{2.5} and PM₁₀ concentrations during the weekdays were 29.58, 53.91 and 69.23 microgram/m³ in respective, while weekday nighttime levels were the means of 24.08, 44.37 and 57.87 microgram/m³ in the street market. During the weekend, daytime PM₁, PM_{2.5} and PM₁₀ mean concentrations were 43.57, 76.72 and 92.83 microgram/m³, while nighttime concentrations were 52.81, 93.56 and 113.27 microgram/m³ for PM₁, PM_{2.5} and PM₁₀, respectively. In general, particulate mass concentrations varied by weekday and weekend, where maximum concentrations during the weekend were higher than those in weekday. Besides, maximum concentrations were about the same magnitude during daytime and nighttime periods, with most of the high levels lying in the particle size of 200-400 nm. For particles with diameter size less than 1 micrometer, particulate number concentrations also differed by weekday and weekend periods. During the weekdays, daytime concentrations were higher than the nighttime levels, whereas the pattern was reversed during the weekend. The main particle size

for number concentrations was in the range of 10-70 nm in the weekdays, compared to the size of 10-200 nm during the weekend. Every night after 8 pm, peak number concentrations lay in the particle size of 20-100 nm, with weekend levels two times higher than the weekday levels, which could be attributed to the impact of human activities during the weekend. Finally, using multi-way analysis of variance, wind speed and wind direction were found to affect PM_{1-2.5} and PM_{2.5-10} concentrations significantly; PM_{1-2.5} concentrations were also affected by ambient temperature. There was no interaction between these factors. As regards to submicron particle concentrations, wind speed was also an influential factor, while the interaction between the factors varied with different particle size ranges.

Chemical speciation of carbonaceous aerosols emitted from peatland fires in Sumatra Island

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Abstract:

In Indonesia, haze caused by smoke from peatland fires frequently occurs in dry season every year. The fires are more pronounced in El Niño years due to biomass dryness under severe drought conditions. The dense haze worsens domestic air quality in Indonesia, and the transported haze affects regional air quality in the surrounding countries such as Malaysia and Singapore. Needed basic information is physicochemical speciation of the fire aerosols and their human health risks with accurate source apportionment in the source and the receptor sites. However, there exist limited data on the chemical characteristics of peatland fire aerosols in the vicinity of the sources.

In this study, a field study to characterize carbonaceous PM_{2.5} emitted from peatland fires using ground-based samplings at fire sources were conducted in the Riau Province, Sumatra, Indonesia in 2015 (El Niño year). We conducted the samplings at three districts, Siak (sampling number, N = 8), Kampar (N = 5), and Payung Sekaki (N = 5). A set of PM_{2.5} sampler (ChemComb model 3500 speciation sampling cartridge, Thermo) equipped with two volatile organic compound denuders to reduce artifacts of organic gases was utilized to continuously collect PM_{2.5} on quartz fiber filters at a flow rate of 10 L/min. After samplings, we determined the concentrations of organic carbon (OC) and elemental carbon (EC), water-soluble organic carbon (WSOC), carbon content of humic-like substances (HULIS-C), and some organic compounds such as polycyclic aromatic hydrocarbons (PAHs) and molecular tracers for biomass burning (e.g., cellulose, hemi-cellulose, and lignin pyrolysis products).

Here, we show one of the results of OC, EC, and molecular tracers. The average concentrations of OC, EC, levoglucosan, mannosan, quantified total lignin pyrolysis products, and total PAHs (US EPA 16 PAHs except for Naphthalene) for all samples (N = 18) were 730, 7.2, 12, 1.0, 6.1, and 1.1 µg/m³, respectively, which showed extreme high concentrations due to the source samplings. Regarding the mass fractions

of quantified chemical species in total carbon (TC), different trends were observed among the sampling locations in most cases. The average EC mass fraction in TC for Siak, Kampar, and Payung Sekaki were 6.0, 16, 25 $\mu\text{g}/\text{mg-TC}$, respectively, which showed the difference among the sampling sites. Levoglucosan and mannosan also showed similar trend to EC. However, interestingly, the differences in total PAHs were not clearly found (Siak: 1.6 ± 0.35 (average \pm standard deviation) $\mu\text{g}/\text{mg-TC}$, Kampar: 1.6 ± 0.43 $\mu\text{g}/\text{mg-TC}$, and Payung Sekaki: 1.2 ± 0.91 $\mu\text{g}/\text{mg-TC}$). Although controlling factors to determine chemical composition of PM_{2.5} for peatland fire have not been known, our results indicate that PM_{2.5} source profile of peatland fire must be selected with extreme caution if applied to a receptor model, such as chemical mass balance or source-oriented chemical transport model.

The migration process and environmental impact of sulfur among the water-tailing-air phase interface at the surface of pyrite tailing reservoir in the typical multi-metal mining city in the Center China

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Abstract:

Mill tailing is a kind of hazardous solid waste of mining. Nowadays the effective method to disposal the mill tailing is landfilling. The mill tailings are pumping to the reservoir with water and stacking up. In that case, the phase interface of water-tailing-air exist at the surface of the reservoir. Moreover the contaminant migrate among these phase interface and change their form to influence the environment. In this research, a pyrite mill tailing reservoir was taken as an object to find out the migration process and environmental impact of sulfur among the water-tailing-air phase interface. The results indicated, the sulfur in pyrite existed as S^{2-} compound with Fe^{2+} . This kind of sulfur was immobilized inside the mill tailings and could hardly impact the environment. On the other hand, while the sulfur contacted with the water, it could be oxidized to oxidation state, such as SO_4^{2-} , by the dissolved oxygen in water. In this case the water could change to acid water. Moreover, it would reduce the pH and quality of soil and groundwater. Also at water-tailing-air phase interface, while the sulfur contacted with the air, it could be oxidized to SO_2 and released to the air. Otherwise the SO_2 could change to SO_4^{2-} and return to the ground by deposition impact the environment. All the results showed the water-tailing-air phase interface is the "source" and "sink" of acid water and impact the environment. The achievements filling the blank of sulfur migration and transformation process at water-tailing-air phase interface at the surface of mill tailing reservoir. Moreover the achievements provided the basic data for acid water formation and environmental impact process.

Korea-China Joint Research on Ambient Air Quality: Ground-based PM_{2.5} monitoring and Source Apportionment

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Abstract:

Substantial economic growth due to the rapid development and urbanization has brought negative impact to the air quality in China. Meanwhile industry, population, and vehicles have grown along with economy in China and exacerbated the air pollution. Exposure to ambient air pollution is known to cause adverse health effects such as mortality and morbidity. One of the most concerned air pollutants is fine particulate matter (PM_{2.5}) due to its ability to penetrate deeply into the lung and cause inflammation which develops into diseases.

With increasing concerns on air quality, China's State Council issued Action Plan on Prevention and Control of Air Pollution on 10th September of 2013. The Action Plan was designed to reduce PM_{2.5} by up to 25% and to maintain PM_{2.5} concentrations in Beijing within 60 µg/m³ in period of 2013 to 2017. With the effort to reduce air pollution, as of 2017, annual average PM_{2.5} concentrations in Beijing was successfully reduced to 58 µg/m³ which is 30% less than that of 2012.

Northeastern China's air quality problem impacts regionally as well as internationally so it is necessary to continue monitoring and studying PM_{2.5} in the region. Thus, in order to better understand the characteristics of PM_{2.5} and transportation pathways in Northeastern China, the ground-based monitoring has been operating as part of Korea-China Joint Research on Ambient Air Quality.

Three channel low-volume air sampler was installed in Beijing on June of 2017. Collected samples were used to measure trace elements (Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Pb, As, and Se), carbonaceous species (OC and EC), and ionic species (SO₄²⁻, NO₃⁻, and NH₄⁺). PM_{2.5} concentrations and chemical constituents were applied to PMF (Positive Matrix Factorization) receptor model for identification of contributing sources. PSCF (Potential Source Contribution Function) was conducted to identify potential source areas. RTA (Residence Time Analysis) was conducted to identify the regions

attributable to the elevated PM_{2.5} concentrations observed in Beijing. For RTA, China was largely divided into seven regions (Northeast China, East China, Central China, South China, Southwest China, Northwest China, and North China) and subdivided into four provinces (Hebei, Shandong, Shanxi, and Henan) which are known to be highly polluted areas. In order to consider long range transport of air pollutants to China, South Korea, North Korea, Japan, Mongolia, Russia, and Kazakhstan were selected to consider long range transport of air pollutants.

Pollution Characteristics and Source Apportionment of Elements in PM_{2.5} during Winter in Panjin City

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Abstract:

In order to explore the sources and characteristics of elements in PM_{2.5} during winter of Panjin city, the PM_{2.5} samples were collected at three monitoring sites in January 2017. Pollution characteristics and source of elements component in PM_{2.5} were analyzed by enrichment factor and factor analysis (FA). The results showed that the order of PM_{2.5} concentration was development zone > the secondary middle school > cultural park. There were 9, 4 and 7 days to exceed the secondary standard limit of the ambient air quality standard (GB3095-2012) (75 μ g/m³) in the three sites respectively during the sampling period. The elements contained in PM_{2.5} were, in descending order, Al, Ca, Fe, Na, Mg, Zn, Pb, Mn, V, As, Cu, Ni, Cr, Cd. The proportion of Al, Ca, Fe, Na, Mg, Zn, Pb accounted for 96.85% of the total determined elements mass concentrations. The pollution levels of Cd, Zn, Pb, As, Cu were extremely high enrichment and Ni, V were very high enrichment. Cr, Ca, Mg were significant enrichment and Mn, Na were moderate enrichment, Fe was slightly enriched. The results of FA showed that the main sources of the pollution elements in PM_{2.5} during winter in Panjin were vehicle exhaust, coal combustion, steel smelting, fuel oil, soil dust.

Geochemical characteristics and source analysis of rare earth elements in dust collected from parks in a coastal scenic city of China

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Abstract:

Aim at determining the spatial-temporal distributions and sources of rare earth elements (REEs) in dust, 96 samples were collected from parks in July and December 2017. REEs were analyzed using the inductively coupled plasma-mass spectrometry (ICP-MS). The concentration of total REEs (\sum REEs) presented higher in winter (range: 123-270 mg/kg; mean: 170 mg/kg) than summer (range: 51-235 mg/kg; mean: 153 mg/kg) and inland (range: 69-234 mg/kg; mean: 163 mg/kg) slightly higher than island (range: 51-270 mg/kg; mean: 160 mg/kg). The coefficient variation of \sum REEs presenting less than 25% showed homogeneous sources of REEs. Chondrite-normalized rare earth elements distribution patterns and La-Ce-Sm 3D-scatter plot demonstrated that REEs in dust from parks were mainly came from traffic source and soil dust, followed by coal combustion. The principal component analysis further indicated that REEs were mainly derived from traffic source and soil dust, with contributions of 77.8% and 13.4%, respectively.

Characteristics of Organic compounds in PM_{2.5} at urban and residential areas of Mongolia during the Winter and Spring

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Abstract:

Aerosol has become the most important agenda among the environmental field in the East Asia. Especially, Mongolia has suffered severe air pollution problem due to increased anthropogenic disturbances such as mining, overgrazing pasture lands, inappropriate usage of crop lands, and deforestation. Also, cold winters that follow a period of drought can lead to a natural disaster called *zud*, a phenomenon of thick snow cover prevent animals from consuming fodder, causing livestock to die of starvation.

In this study, we investigated the characteristics of air pollutants in Mongolia, focusing on the organic compounds distribution in PM_{2.5} at Ulaanbaatar, a capital city in Mongolia. PM 2.5 samples were collected in 'NAMEM(National Agency of Meteorological and Environment Monitoring of Mongolia)' and 'BKH(Bayankhoshuu)' of Ulaanbaatar to carry out organic speciation. 'NAMEM' is located in the center of Ulaanbaatar. 'BKH' is a residential area dominated by traditional Mongolian yurt dwelling houses, Gers. The sampling was conducted for each of two weeks(23hrs per day) during November of 2017 and March of 2018 to get samples of the winter and spring. Then, we analyzed five groups of organic compounds which are PAHs, n-Alkanes, n-Alkanoic acids, Dicarboxylic acids and Sugars. Total average concentrations of organic compounds in the winter was higher than in the spring. In addition, the concentrations of these compounds were higher at the suburban(called ger district) than the center of Ulaanbaatar. It was estimated that the main emission source of Ulaanbaatar was coal combustion during the winter based on the PCA analysis of organic compounds. In this study, the possibility that the air pollutants in Ulaanbaatar will be transported to other areas in Northeast Asia will be discussed. .

PM_{2.5}, Black Carbon, Particle Number Concentrations and the Characteristics of Particle Mass and Number Size Distributions at Two Traffic Sites in Taipei City.

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Abstract:

The concentration levels of suspended particulate matters in the atmosphere have been gradually attracted by public attention. Because these suspended particulate matters have negative implications for human health and environment, especially for the citizens living near emission sources. The transportation is the major pollution source of the particulate matters in the urban area. Therefore, this study measured the PM_{2.5}, black carbon (BC), particle number concentrations, and particle size distributions at two traffic sites in the Taipei urban area. The samplings were performed from April 29, 2016 to May 9, 2017.

The measurement results showed that the PM_{2.5} concentrations at site 1 and site 2 were 20.3 ± 12.6 and 17.4 ± 10.3 $\mu\text{g}/\text{m}^3$, respectively, and the levels of PM_{2.5} between site 1 and site 2 were not significantly different. The level of PM_{2.5} in the spring was significantly higher than that in the summer at site 1 ($p < 0.05$). Otherwise, the levels of PM_{2.5} among other seasons were not significantly different. At site 2, the concentrations of PM_{2.5} were not significantly different among the four seasons. The BC mass concentrations at site 1 and site 2 were 2.62 ± 1.96 $\mu\text{g}/\text{m}^3$ and 2.44 ± 1.43 $\mu\text{g}/\text{m}^3$, respectively. The black carbon mass concentrations between these two sites were not significantly different. However, it is clear that BC mass concentration in the summer was the highest (all $p < 0.05$), while the BC mass concentrations among other three seasons were not significantly different at site 1. The BC mass concentrations in the spring and summer were significantly higher than that in the winter ($p < 0.05$), but the BC mass concentrations were not significantly different between the spring and summer at site 2. The particle number concentrations at site 1 and site 2 were $3.3 \times 10^4 \pm 2.2 \times 10^4$ and $2.6 \times 10^4 \pm 1.1 \times 10^4$ particles/cm³, respectively. The particle number concentration at site 1 was 1.3 times significantly higher than that at site 2 ($p < 0.05$). The measurement results showed that the particle number concentration in the summer was the highest and significantly higher than those in other seasons, while the particle number concentrations among the spring, autumn and winter were not significantly different at both site 1 and site 2. Measurement results showed that the particle mass size distributions at site 1 and site 2 exhibited a bi-mode pattern. The dominant mode was at approximately 0.3 μm , and the secondary mode was at approximately 3.5 μm . In addition, the particle number size distribution at site 1 exhibited a mixed-mode pattern combined with two log-normal distributions, including a main mode at approximately 0.03 μm and a sub-mode at approximately 0.15 μm . Moreover, the particle

number size distribution at site 2 showed a single-mode pattern and the mode was at approximately 0.035 μm .

Role of trees in altering air quality in small urban parks

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Abstract:

Air quality in small urban parks improves rapidly with distance from surrounding streets. There is a general view among those who manage urban infrastructure that the improved air quality in parks results from the uptake of pollutants by vegetation. However, measurements available from the literature and modelling studies offer only limited support to this view. The rapid decline of pollutant concentrations could potentially arise from dispersion, deposition and transformation. The balance between these factors is not always carefully considered. In particular, the role of vegetation in improving air quality may be over emphasized when considering choice of layout of vegetation and human exposure in urban green spaces. Here we explore the decline in concentration of traffic derived pollutants as they disperse into urban parks and assess the balance between deposition to vegetation and advection-diffusion processes. It is increasingly evident that relatively little pollution is absorbed by trees over short distances typical of small urban parks and trees can also reduce wind speed and potentially trap pollutants. Nevertheless, trees provide a range of other important ecosystem services, so are to be encouraged. Appropriate planting strategies have the potential to mitigate their negative effect on air quality. The relation between planting design and pollutant dispersion starting from field surveys in urban parks in Hong Kong was explored. A series of indicators associated with tree morphology and landscape were derived from the surveys and their influence on air pollutant distribution in parks examined using simple CFD modelling. Trees with different crown heights and leaf area density play different role in changing pollutant dispersion in parks. The distribution of stands with varied sizes also altered the airflow in parks. Our results suggested a planting strategy regarding the aerodynamics of trees should be considered to optimize air quality in urban parks.

Keywords: decay profile, line source dispersion, pollutant transformation, near road environment, vegetation uptake

Profiling Vertical Distributions of Fine Particulate Matter (PM_{2.5}) and Black Carbon (BC) Using an Unmanned Aerial Vehicle (UAV) in Macao, China

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Abstract:

Unmanned aerial vehicles (UAVs) is a fast-developing method with high cost-efficiency, flexibility, and mobility for vertical profile measurements of airborne particles. Measurements using UAVs can provide essential information for understanding the spatiotemporal characteristics of particulate matters (PM) in atmosphere^{1,2,3}. In this work, 12-day and 11-day measurements were conducted during February and March 2018, respectively, in Macao to depict the vertical distribution of fine particulate matter (PM_{2.5}) and black carbon (BC). In total, 46 flights were carried out between 5 am and 6 am. In our measurements, concentrations of PM_{2.5} and BC were significantly lower in March ($36.0 \pm 18.7 \mu\text{g m}^{-3}$ and $2.3 \pm 2.0 \mu\text{g m}^{-3}$, respectively) with easterly winds than those in February ($46.7 \pm 21.5 \mu\text{g m}^{-3}$ and $3.6 \pm 2.0 \mu\text{g m}^{-3}$, respectively) with northerly winds. In general, PM_{2.5} concentration decreased along height, while the more scattered BC concentration showed a significantly varying vertical profile. Besides, UAV flights coinciding with the take-off of a civil flight on February 10th and on March 17th (Flight No.: QFA7534 and LKH7219, respectively) resulted in a high concentration of airborne particles (particularly PM_{2.5}) at an altitude of ~ 300 m. Such an effect was also witnessed on Chinese New Year (Feb 16th) when there was a large amount of firework and firecracker performance. In addition, most maximum concentrations of PM_{2.5} (35/45) were monitored under 100 m, with 7 cases over 400 m. In comparison, 23 (out of 46) cases were recorded near ground (below 100 m) and 14 cases were higher than 300 m for maximum concentrations of BC. The distribution of maximum BC/PM_{2.5} values presented more elevated appearance in atmosphere. 28 (out of 45) cases were found above 300 m, in which 17 cases higher than 400 m. These results implied the difference between the movement of BC and PM_{2.5} in atmosphere. On the other hand, temperature and relative humidity (RH) mostly decreased with increasing height in our measurements, making it more favorable for the generation of secondary pollutants in the lower atmosphere (< 100 m).

KEYWORDS: PM_{2.5}, black carbon, vertical profile

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Seasonal Variations and Source Apportionment of the Water-Soluble Inorganic Ions in Fine Particulate Matter in the Typical Coal-Fired Industrial City

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Abstract:

In order to explore the pollution level and water-soluble ion characteristics of fine particulate matter (PM_{2.5}) in different seasons in Handan city, a typical coal-fired industrial city, PM_{2.5} samples were collected by a multi-channel air particulate sampler (UnrayZR-3930D) in 2016. Water-soluble ions were measured by ion chromatography (IC), and the variation characteristics of water-soluble ions changing with PM_{2.5} concentrations in different seasons were analyzed. The result showed that the main water-soluble ions in four seasons were NO₃⁻, SO₄²⁻, and NH₄⁺. The detail orders were as following: NO₃⁻ > SO₄²⁻ > NH₄⁺ > Na⁺ > Cl⁻ > K⁺ > Ca²⁺ > Mg²⁺, NO₃⁻ > SO₄²⁻ > NH₄⁺ > Cl⁻ > K⁺ > Ca²⁺ > Na⁺ > Mg²⁺, SO₄²⁻ > NH₄⁺ > NO₃⁻ > K⁺ > Cl⁻ > Na⁺ > Ca²⁺ > Mg²⁺, and NO₃⁻ > SO₄²⁻ > NH₄⁺ > Cl⁻ > Na⁺ > K⁺ > Ca²⁺ > Mg²⁺ in spring, summer, autumn, and winter, respectively. According to the correlation analysis, PM_{2.5} was found to be acidic in spring, summer and autumn, respectively, and alkaline in winter. Based on the principal component analysis, water-soluble ions were mainly from secondary transformation, industrial sources, combustion sources, soil construction dust and so on.

Characteristics and Formation Mechanism of a Heavy Winter Air Pollution Event in Tangshan.

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Abstract:

Abstract: The aim of this study is to investigate characteristics and formation mechanism of heavy air pollution event in Tangshan, Hebei Province. A typical heavy pollution process from December 27th to 31st, 2017 is selected to be analyzed. Combined with the mass concentration of particulate matter, gaseous pollutant concentrations, carbonaceous species and meteorological data, the component analysis of PM_{2.5} is conducted in detail for this episode. The results show that PM_{2.5} is the primary pollutant, and its hourly average mass concentration exceeds the standard of 69% and the peak concentration reaches 271 $\mu\text{g}\cdot\text{m}^{-3}$ during the pollution period; the heavier the pollution is, the higher the value of PM_{2.5}/PM₁₀ becomes; the mass concentration of SNA from PM_{2.5} accounts for 58.0%, and mainly in the presence of NH₄HSO₄ and (NH₄)₂SO₄ and nitrate; the value of OC/EC is 4.1, indicating that the secondary reaction of particulate matter and organic matter have a greater contribution in this pollution process; the influence of regional transmission should not be ignored. The HYSPLIT analysis shows that the air mass from the south part of Hebei Province and the inland areas of central China has a certain impact on the aggravation of Tangshan's pollution process.

Key words: heavy pollution, PM_{2.5}, Tangshan, pollution characteristics, water-soluble inorganic ions

Elevated number and mass concentrations of fine particles during winter 2018 in urban Gwangju, Korea

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Abstract:

Fine (<2.5 μm) and ultrafine (<100 nm) particles are of current interest due to their effects on radiation balance and cloud formation (Takami et al., 2005). Also, they significantly affect human health. It is important to understand source and formation pathways for fine and ultrafine particles elevated in urban ambient atmosphere (Song et al., 2010; Wagstrom and Pandis, 2011). An intensive measurement was conducted during the winter of 2018 (1/3-2/2) at urban Gwangju, Korea (35.23° N, 126.84° E). Number concentrations of fine and ultrafine particles were measured with a scanning mobility particle sizer (SMPS) which includes differential mobility analyzer (DMA) (3085, TSI, USA) and condensation particle counter (CPC) (3022, TSI, USA), and an optical particle counter (OPC) (1.108, Grimm, USA). Mass concentration of black carbon (BC) was measured with an aethalometer (AE-31, Magee, USA). Mass concentration of particulate matter less than 2.5 μm (PM_{2.5}) was measured with OPC. Chemical characteristics of PM_{2.5} (ions, elements, and organic carbon (OC), and elemental carbon (EC)) were also determined for daily filter samples. Average number concentrations (particles/cm³) of particles in size ranges of 20-100 nm, 20-700 nm, and 0.3-2.5 μm were 2355 (\pm 1452), 4038 (\pm 2085), and 159 (\pm 131), respectively. Average mass concentrations ($\mu\text{g}/\text{m}^3$) of PM_{2.5} and BC were 10.96 (\pm 3.85) and 1.19 (\pm 0.83), respectively. Five new particle formation (NPF) events (elevated number concentration of ultrafine particles (<100 nm) with subsequent growth) and three PM_{2.5} event days (elevated PM_{2.5} mass concentration) were observed. It was found that NPF event days were not identical with the PM_{2.5} event days. Various characteristics of NPF and PM_{2.5} concentration events at urban Gwangju are being investigated.

Measurements of particulate matter inside and around skyways

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Abstract:

Hong Kong has developed an extensive network of pedestrian skyways in order to alleviate street traffic and pedestrian congestion.

Intuitively, the air quality may be better inside skyways than at street level due to the increased distance from traffic-related emissions.

However, measurements of PM_{2.5} and PM₁₀ using portable air quality monitors confirm that this is not true in all cases.

The objective of this study is to determine whether pedestrians using the skyway experience lower exposure than those utilizing the sidewalk below.

PM concentrations at street level and inside different skyways are compared.

The average sidewalk PM concentration is slightly higher when the skyway is parallel to its street.

Among skyways perpendicular to the street, the concentration inside the skyway is usually but not always lower.

The PM concentration ratio ($C_{\text{sidewalk}}/C_{\text{skyway}}$), which normally lies between 1 to 1.5, varies according to the type of skyway, such as ones with railing or sidewalls and ones with a cover or not.

Size distribution of elemental components in aerosols from typical industrial and mineral city

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Abstract:

Concentration levels, particle size distribution and possible emission sources of various elements in aerosols from typical industrial and mining city were discussed. Sampling site was set up on the roof of the School of Environmental Science and Engineering, Hubei Polytechnic University. Samples with various particle sizes were collected using Anderson class 8 particle impact sampler throughout one year. Samples were collected during one month in each season, and a total of 135 effect samples were obtained during one year. The concentration of airborne particulate matter increased significantly with the decreasing in particle size. Therefore, higher concentrations were mainly concentrated in the fine particle size segments, such as $17.21\mu\text{g}/\text{m}^3$ ($0\sim 0.4\mu\text{m}$), $19.52\mu\text{g}/\text{m}^3$ ($0.4\sim 0.7\mu\text{m}$), and $16.97\mu\text{g}/\text{m}^3$ ($0.7\sim 1.1\mu\text{m}$). The particle mass concentrations in different particle sizes showed high values in winter and low values in summer, which was obviously affected by rainfall and relative humidity. Energy dispersive X-ray fluorescence spectrometry was used to determine the concentrations of 17 elements. The results showed that Ca, S, Fe, K, Zn, Ba, and Pb elements were the main pollutants in the airborne particles in Huangshi City during the sampling period. Among them, the concentration of Ca was the highest, and its concentration in coarse particles was higher than that in fine particles. Some of the major elements, Ca, K, and Fe, were 5 to 10 times more than those of Beijing and Chongqing. Other elements (such as Ti, Cr, and Mn) were slightly higher than those of Beijing and Chongqing. While other elements, such as Co, Ni, V, etc., were equivalent to those of Beijing and Chongqing. In addition, each element also showed obvious characteristics of particle size distribution and seasonal variation. Specifically, the peaks of 11 elements, such as Ca, Fe and K, appeared at the size of $5.8\sim 9.0\mu\text{m}$, while the peaks of the other elements mainly appeared at the size of $0.4\sim 1.1\mu\text{m}$. The highest concentration of each element in the coarse and fine particle size was mostly distributed in $5.8\sim 9.0\mu\text{m}$ and $0.7\sim 1.1\mu\text{m}$, respectively. In general, the larger the size of atmospheric particles, the higher the total accumulation of elements. The seasonal characteristics were specifically represented by the high concentrations in spring and winter and low values in summer and autumn. The enrichment factor analysis results showed that the enrichment factor value of S was the largest, and the element Ca was moderately enriched. Cl was

highly enriched in three particle sizes ranging from 0~1.1 μm , while moderately enriched in the other six sizes. The remaining elements were slightly enriched in each particle size. The principal components analysis method was used to make preliminary judgment on the sources of various elements in atmospheric particles. The analysis results showed that the main sources of atmospheric particulates in Huangshi City were as follow, crust, coal combustion, biomass combustion, waste incineration, motor vehicle exhausts, the floating dust from mining construction, road dust and the emission from metallurgical and chemical companies.

Turbulent Flow and Pollutant Dispersion inside Elevated Walkway Microenvironments

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Abstract:

Knowledge of turbulent flow and pollutant dispersion in idealised urban canyons may not be fully applicable to the understanding of urban ventilation and roadside exposure in elevated walkway microenvironments, in which the flow and scalar dynamics could be more complicated and the results differ qualitatively from that in canyons where walkways are absent. This work investigates the turbulent flow around the walkways and the transfer of pollutants into walkway interiors using large-eddy simulation (LES). Different walkway designs (with impermeable sidewalls and cover, no sidewalls but cover, no sidewalls and cover) and walkway heights, H_{ww} (with respect to the building height, H , $H_{ww}/H \sim 0.3, \sim 0.5, \sim 0.7$) are examined for a unit-aspect-ratio street canyon.

The walkway is surrounded by two vortex pairs in a quadrupole pattern and, by contrast with the no-walkway case, the scalar field shows considerable inhomogeneity along the street. Although pollutant concentration in the pedestrian region appears to be less influenced by the walkway, air quality inside and around the walkway interior exhibits great sensitivity to the walkway design and height. It is argued that impermeable sidewalls can be responsible for pollutant trapping inside the walkway and uncovered walkways can allow more fresh air into the canyon (hence improves ventilation); the results favour walkways positioned below the middle of the building height ($H_{ww}/H \sim 0.3$). This work offers guidance to the design and positioning of new walkways inside urban canyons.

Quantifying gaseous contaminants from PM_{2.5} by Soft X-ray Radiolysis

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Abstract:

PM_{2.5} (Particulate matter smaller than 2.5 μm in aerodynamic diameter) is one of important global air pollution issues, threatening the environment and human health as well as the semiconductor industry. Even though air filters eliminate PM_{2.5} of the outdoor air, gaseous contaminants can be outgassed from PM_{2.5}, thus reducing the lifetime of gas filters installed next to the particulate air filters. Once the breakthrough of the gas filters occurs, the outgassing can smear into the semiconductor manufacturing processes, and then work as airborne molecular contamination (AMC), which causes defects on the semiconductor chips by producing particles and haze. Therefore, estimating the concentration of the outgassing from PM_{2.5} is very important to control the level of AMC in the semiconductor industry. In this study, PM_{2.5} was sampled in Xi'an, China, at different mass concentrations and evaluated through the soft X-ray radiolysis method for determining the correlation between the PM_{2.5} mass concentration and the level of outgassing. The chemical composition of the PM_{2.5} samples were also analyzed by organic and elemental carbons (OC/EC), water soluble ions and organic compounds. The outgassing quantified through the soft X-ray radiolysis method increased with the mass concentration of the PM_{2.5} sample. In addition, the chemical analyses showed that the level of OC was strongly related with the outgassing measured by the soft X-ray method.

Development of PM₁₀, PM_{2.5} cyclones for sampling inlet of large stationary sources in Korea

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Abstract:

In Korea, the US EPA 201A method (cyclone method) is used as a Korea standard test method for measuring particulate matter (PM₁₀, PM_{2.5}) in flue gas emitted from large stationary emission sources. In order to use Korea standard test method, it is necessary that the diameter of sampling port must be larger than 160 mm. However, most of the sampling port applied to Korea large stationary sources is smaller than 160 mm, which makes difficult to apply the Korean standard test method. In addition, the US EPA 201A method has a drawback that long-term sampling is required for the quality control. The ISO 23210 method (cascade method) is applicable even when the diameter of the sampling port is less than 160 mm, and it measures PM₁₀ and PM_{2.5} simultaneously, but it is not available for TPM measurement and has difficulty in sampling. In this study, we developed the US EPA201A based cyclone for measuring PM₁₀ and PM_{2.5} even in the sampling port size smaller than 160 mm in order to reduce the cost and inconvenience to install and remodel the current sampling port. We evaluated the new cyclone by computational fluid dynamics model, then conducted lab-scale test using Arizona find dust.

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Analysis of different types of air pollution episodes in Northwestern China

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Abstract:

Three different pollution events occurring in Lanzhou, China during 2015-2016 were analyzed based on the ground-based solar photometer data, meteorological observations, and atmospheric environmental monitoring data: episode 1: Dust storm (18-22 Feb, 2016), episode 2: coarse particle haze [PM₁₀: $D_p \leq 10 \mu\text{m}$, (17 Jan, 2016)], and episode 3: fine particle haze [PM_{2.5}: $D_p \leq 2.5 \mu\text{m}$ (30 Nov, 2015)]. The results showed that the dominant wind direction of the surface wind with all pollution events is easterly wind and the overall wind speed is $< 4\text{m/s}$, and some are even $< 1\text{m/s}$. The lower wind speed will affect the spread of pollutants and contribute to the accumulation of pollutants in the area. The backward trajectory frequency analysis of pollution events indicates that regional-scale aerosol transport may have a significant impact on Lanzhou pollution events. In three pollution events, the air mass is active in different dust sources and carries a large amount of aerosol particles. During the episode 1, PM_{2.5}/PM₁₀ was around 0.2, AOD_{500nm} was severely polluted above 1.2. Relative humidity has a significant daily variation, but the overall is $< 35\%$. During the episode 2 the PM₁₀ was significantly higher than the PM_{2.5}, and the PM_{2.5}/PM₁₀ ratio the maximum is no more than 0.4. AOD_{500nm} value was above 0.4, but most of them were less than 0.8. The episode 3 PM_{2.5}/PM₁₀ is mostly greater than 0.5, the AOD_{500nm} value is more than 0.7, Ångström parameter (α) varied from 1.22 to 1.34 with an average of 1.28. The relative humidity and water vapor content are consistent during the two haze period. AOD along with can be used to Ångström parameter (α) determine the aerosol types. The episode 1 had the highest AOD and the lowest α . The α value of episode 2 (0.77) was smaller than episode 3 (1.28), indicating that coarse particles were dominant in the former type. The results of this study will help us better understand the aerosol characteristics of different types of pollution events in northwestern China.

A sampling and measurement system for motorcycle exhaust

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Abstract:

Traffic emission is an important anthropogenic source of air pollutions, such as fine & ultrafine particulate matters and gaseous pollutants. Motorcycle becomes even more popular nowadays because of convenience, mobility and economy. Statistics indicated that the motorcycle density in Taiwan is 378/km², the highest in Asia. To monitor and control the particulate matter emission of in-use motorcycle is a critical and important means to improve the air quality.

The standard method to measure emission was use CVS (Constant volume sampling) to measure the engine emission with the standard driving cycle. However, the CVS system had drawbacks of high cost, large volume and complex system. The purpose of this study is to develop a real-time, low cost and simple method to measure vehicle PM emission.

This study was divided into two parts: sampling train development and exhaust measurement. The sampling was composed of an adapter connecting to the tailpipe, the PM_{2.5} selector, and the dehumidifying device. The exhaust was cooled by a PM_{2.5} selector soaked in an ice-water bath, then pass through the diluter to dilute particulate matter concentration. Emission measurement from motorcycle using the scanning mobility particle sizer (SMPS, model 3080, TSI Inc.), condensation particle counter (CPC, model 3022A, TSI Inc.), aethalometer (model microAeth AE51, AethLabs Inc.) and gas analyzer (model BE-2000, Belltone Inc.) were used to measure particle size distribution, number concentration, black carbon concentration and gas pollutants concentration.

The performance of the dehumidifying device and diluter was evaluated in this study due to exhaust high humidity, temperature and concentration. The water contents of motorcycle exhaust are 5.3 % and 8.1% at 1750 rpm (idle) and 4000 rpm speed. The cooling and dehumidification efficiency of ice bath can decrease the exhaust temperature close to room temperature, and relative humidity can decrease to 80 %. The test of dilution ratio on diluter using particle generator to generate particle size from 15 nm to 720 nm. When the dilution factor condition at 10 times, the temperature and relative humidity of exhaust can decrease to room temperature and 45 %. The results indicated that the engine emission at idle mode had a GSD of 1.8, and number concentration of 104-106 #/cm³. BC mass concentration at idle

mode had 1-10 $\mu\text{g}/\text{m}^3$. The gas analyzer provides O₂, CO, CO₂, NO_x, and HC information, at idle mode, the concentration is 16 %, 0.27 %, 3.1%, 13 ppm and 26 ppm respectively.

Mercury Contents of PM_{2.5} at a Suburb Site and a Mountain Site in Taiwan

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Abstract:

Mercury (Hg), a persistent and bioaccumulative pollutant of global concern, is dispersed worldwide mainly via atmospheric transport. Besides its primary form as gaseous elemental mercury (GEM), atmospheric Hg also exists as gaseous oxidized mercury (GOM) and particulate-bound mercury (PBM). Despite PBM is usually a minor fraction of total atmospheric Hg, it could be a significant Hg source to terrestrial and aquatic ecosystems via wet and dry deposition. Mercury contents of PM_{2.5} (PBM_{2.5}) at a suburb site (National Central University, NCU) in northern Taiwan and a mountain site (Lulin Atmospheric Background Station, LABS) in central Taiwan have been measured using a Tekran atmospheric Hg speciation unit. At the LABS, the mean concentration of PBM_{2.5} was 3.7(±9.4) pg.m⁻³ between April 2006 and December 2016. This is significantly lower than values reported from mountain sites in China, such as Mt. Changbai (18.9 pg.m⁻³), Mt. Ailao (31.3 pg.m⁻³), Mt. Waliguan (19.4 pg.m⁻³) and Mt. Gongga (30.7 pg.m⁻³), but it is comparable to the value of Mt. Bachelor (5.2 pg.m⁻³) in the US. PBM_{2.5} values were higher in winter and spring than in summer due to the influences of biomass burning in Indochina Peninsula and anthropogenic activities in China. Concentration-weighted trajectory (CWT) indicated that the eastern part of China and northern Indochina Peninsula were the major source regions. At NCU, PBM_{2.5} concentrations ranged from <MDL to 2073.7 pg m⁻³ with a mean of 18.7(±86.8) pg m⁻³ between October 2017 and September 2018. Mean PBM_{2.5} value was 5 times the LABS value. This mean value is much lower than those of urban sites in China, such as Guiyang (368 pg m⁻³) and Xiamen (174 pg m⁻³). On the other hand, it is comparable to values reported from urban sites in North America (2.5-25.4 pg m⁻³) and Europe (12.5 pg m⁻³). Wind rose indicated elevated PBM_{2.5} values associated with SSW and S wind, suggesting local sources to the SW or S of the monitoring site. A Chinese haze event impacted Taiwan since the morning of December 31, 2017 that lasted until the night of the same day. Concentrations of PM_{2.5} all over Taiwan were significantly increased and concurrent 15-fold increases in PBM_{2.5} levels were observed at NCU, demonstrating the influence of transboundary transported Chinese haze on the concentration and speciation of atmospheric Hg in Taiwan.

Chemical characteristics and sources of particulate organic matter in atmospheric PM_{2.5} across the Taiwan strait

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Abstract:

For the past few years, there has been increasing concern about the interaction of PM_{2.5} pollution around the Taiwan Strait. Based on simultaneous observations at seven different sites in Fuzhou, Xiamen and Taiwan, this study comprehensively investigated the chemical characteristics, spatial and temporal variations as well as sources of particulate organic matters (POM) in PM_{2.5} across the Taiwan Strait.

Atmospheric PM_{2.5} samples were collected at seven selected stations in May 2018, including three rural sites (GS/Fuzhou, BH/Xiamen, NCU/Taiwan), two urban sites (EMC/Fuzhou, IUE/Xiamen) on the both sides of the Taiwan Strait and two offshore islands (JM/Taiwan, PH/Taiwan). A total of 134 organic species in 16 subclasses were quantified using Gas Chromatography-Mass Spectrometer (GC-MS). The temporal variations of POM at different sites across the Taiwan Strait followed similar trends. Two pollution episodes were identified during the observation period, when the POM concentrations elevated to twice of those during clean periods. According to the firepoints map and backwards trajectory analyses, the pollution could be attributed to unfavorable meteorological conditions and enhanced local emissions. The airmasses moved slowly on 13 May, swirling around the Taiwan strait. Meanwhile, biomass burning emissions were also observed, as firepoints emerged around these areas.

The average concentration of POM in Fuzhou was 0.39 µg/m³, followed by Xiamen (0.26 µg/m³) and Taiwan (0.13 µg/m³), lower than those in Beijing, Ningbo and Wangdu (0.50 ~ 1.49 µg/m³) reported in other studies. Compared with other regions in mainland China, the proportions of PAHs and n-alkanes in POM were lower across the Taiwan Strait, while that of dicarboxylic acids and alkanolic acids were higher, indicating more contributions from secondary formation and less from primary emissions across the Taiwan Strait.

To further recognize the differences in source contributions across the Taiwan Strait, sources of POM were apportioned based on various organic molecular markers. The contribution of motor vehicles to POM was relatively higher in Fuzhou and Xiamen, while in Taiwan coal combustion was more dominant. Obvious influence of biomass burning was also observed in Fuzhou and Taiwan. The contribution of wood combustion was relatively higher in rural sites or offshore islands than that in urban sites. The different source contributions could be attributed to different energy policies and demographic situations.

This work highlights the specific quantification and source apportionment of various particulate organic matters, as well as the spatiotemporal analysis of atmospheric aerosols across the Taiwan Strait based on field observations.

Investigation of three growth patterns of new particles to CCN size in Beijing

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Abstract:

New particles with mobility diameter (D_p) less than 50 nm require unrealistically high water vapor supersaturations (SS) to activate as cloud condensation nuclei (CCN), while they can be activated to CCN with the D_p beyond 50 nm at $SS \geq 0.4-0.6\%$. With the size of new particles larger than 80 nm, they can be activated as cloud condensation nuclei (CCN) at the normal SS , e.g., $SS=0.2\%$. In this paper, we studied new particle formation (NPF) events occurring in the urban atmosphere in Beijing during three periods, i.e., eight days in winter in 2011, fifteen days in spring in 2012 and three months in summer in 2014. We adopted 50 nm as a threshold to roughly judge whether the grown new particles can be activated as CCN. In winter, the geometric median diameter (D_{pg}) of grown new particles always had no apparent growth through the events with the duration 5-10 h. In spring, the D_{pg} of grown new particles increased up to approximately 50 nm in 4 out of 7 NPF events, leaving 3 of 7 events having no apparent growth through the events with the duration 6-10 h. In summer, an apparent growth of new particles were observed in 24 out of 29 NPF events and the D_{pg} at least in eleven events grew larger than 50 nm, depending on the availableness of data. However, no apparent growth of new particles was also observed through the leaving 4 events with the duration 2-6 h. Regarded the NPF events with the D_{pg} of new particles growing beyond 50 nm, we clearly identified three distinguishing growth patterns. New particles continuously grew with the D_{pg} larger than 50 nm at an almost constant growth rate in 4 of 11 NPF events. The growth pattern is referred as one-stage growth. In 4 of 11 NPF events, new particles grew with the D_{pg} closer to 35-60 nm, stopped the growth for a few hours and then restarted the growth to be larger than 50 nm. The growth pattern is referred as two-stage growth-A. In 3 of 11 NPF events, new particles grew with the D_{pg} closer to 35-77 nm, shrank with the D_{pg} decreasing to 24-50 nm, and then restarted the growth to the size larger than 50 nm. The growth pattern is referred as two-stage growth-B. We investigated these growth patterns of new particles in terms of the seasonal dependence, correlations with gaseous pollutants, coefficient of variation (CV) metric and planetary boundary layer height (PBLH).

VOCs characteristics and ozone potential analysis in typical pollution process in Shenzhen, China

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Abstract:

Ozone pollution is becoming a serious air quality problem in Pearl River Delta region in recent years. The characteristics of ozone and ozone precursors pollution in the Pearl River Delta region have received much attention and research effort. However, such studies with the focus on the ambient air of Shenzhen are relatively few. In this study, the temporal and spatial variation characteristics of ozone and ozone precursor VOCs concentrations in the pre-, mid- and later-stage of typical pollution occurrence in Shenzhen were analyzed. The change patterns of ozone formation potential in different pollution stages were analyzed in order to establish the relationship between ozone formation potential and the ozone concentrations.

Keywords: volatile organic compounds(VOCs) ozone typical pollution fotation potential

Formation of highly oxygenated multifunctional compounds from photosensitized transformation of glyoxal: An insight at a molecular level

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Abstract:

Though it has been widely recognized that the aqueous-phase chemistry of carbonyl compounds in the atmosphere (e.g., cloud droplets, fog, aerosols) is dominated by photochemical processes driven by hydroxyl radical (OH), increasing evidence suggests that photosensitized chemistry also have a significant impact on the transformation of carbonyl compounds, especially into secondary organic aerosols (SOA) through photo-induced generation of high-molecular-weight compounds. However, these compounds are mostly unexplored due to the demanding challenge for analyzing the broad and complex intermediates/products, not to mention the formation mechanism of SOA.

In this study, the photosensitized reaction of carbonyl compounds was investigated at the molecular level by means of two state-of-the-art, ultrahigh-resolution mass spectrometric instruments: Orbitrap Fusion Trihybridmass Spectrometer (ORBITRAP) and Ultrahigh-Resolution Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometer (FT-ICR-MS). Glyoxal (GL), a typical carbonyl compound and pyruvic acid (PA), an extensively studied photosensitizer, were selected as probe compounds.

An unexpected large number of highly oxidized multifunctional organic compounds were unambiguously identified, which illustrates the progression from C₃ to C₂₀ molecules. The possible transformation mechanism investigated by quantum-mechanical calculations using density functional theory (DFT) by the Gaussian 03 suite of programs, suggests that these compounds are thermodynamically more likely from the cross-reactions between PA and GL rather than from the self-reactions of PA. We are confident that the better understanding in the formation mechanism of GL into these highly oxidized

multifunctional compounds, as shown here, will provide a new insight into the change in the physical-chemical properties of the atmospheric aqueous phase and also the sources of SOA.

Atmospheric PM_{2.5}-bound water-soluble ions during the 2017 Yan-Shuei Lantern Festival

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Abstract:

Many studies have confirmed that elevated concentrations of PM_{2.5} were found in ambient atmosphere during and shortly after fireworks displays. Fireworks burning may raise the level of fine particulate matter which contains water-soluble ions, metallic elements, and organic compounds, and these tiny particles may cause adverse effects on human health. To compare the difference in concentration of fine particulate matter before and after shooting off fireworks (SOF) during the Lantern Festival in 2017 at Yan-Shuei and Sin-Ying District, Tainan, the PQ200 air samplers were used to collect the PM_{2.5} at the locations of a dense area (2 sampling stations, Z1 and Z2), a leeward area (3 sampling stations, L1, L2 and L3) and a windward area (3 sampling stations, W1, W2 and W3) during four periods: before, beginning, during, and after SOF. The concentration of PM_{2.5} before SOF is referred to that of background. The results show that the PM_{2.5} concentration range at the eight sampling sites was from 35.5–44.6 µg/m³ and the average concentration was 40.4 µg/m³, but those during firework exceeded the Taiwan's National PM_{2.5} Quality Standards (35 µg/m³ over a 24-hour period). During firework display, the concentrations of PM_{2.5} at Z1 and Z2 were 3.5- and 9.3-time that of the criteria, respectively. At the beginning and intensive SOF, the concentrations of PM_{2.5} at upstream and downstream were 1.2–1.4-time and 1.1–2.0-time that of the criteria, respectively. During SOF, the concentrations of PM_{2.5}-bound K⁺ (13.4–416.7-time), Cl⁻ (8.8–24.8-time), Mg²⁺ (3.0–62.8-time) and NO₃⁻ (6.4–9.7-time) at Z2 (dense area) were significantly higher than those of the other 7 stations. The significant increases of these ions in PM_{2.5} were likely owing to the chemicals (KNO₃, KClO₄, KClO₃, K₂Cr₂O₄, and K₂Cr₂O₇) used as oxidants to strengthen the color of the flame in fireworks. In order to make the fireworks show different colors when they are displayed, some metals are usually added in

fireworks. For example, magnesium powders can produce white light when burning. To conclude, the significant increases in PM2.5 concentration during the SOF period should be concerned for their adverse effects on human health.

Heterogeneous Oxidations of Secondary Organic Tracers of Isoprene and Toluene with Ozone

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Abstract:

Heterogeneous Oxidations of Secondary Organic Tracers of Isoprene and Toluene with Ozone

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ABSTRACT

The tracer-based method has been widely used to assess contributions of an individual gas precursor to the mass of secondary organic aerosols. However, due to possible occurrence of heterogeneous oxidations of the tracers employed in the atmosphere, the accuracy of this method for source apportionment has been questioned. In this study, chamber experiments were carried out to investigate the oxidations of secondary organic tracers of toluene and isoprene (2,3-dihydroxy-4-oxopentanoic acid (DHOPA) and 2-Methyl erythritol (2-ME)) as well as the analogue of 2-Methyl erythritol (AME) with ozone under different conditions (relative humidity and mixing state etc.) using a relative rate constants approach. The results showed that the effective rate constants of analogue of 2-methyl erythritol(AME) and 2,3-dihydroxy-4-oxopentanoic acid(DHOPA) were $(4.60 \pm 0.66) \times 10^{-19} \text{ cm}^3 \cdot (\text{molecule} \cdot \text{s})^{-1}$ and $(6.57 \pm 0.51) \times 10^{-19} \text{ cm}^3 \cdot (\text{molecule} \cdot \text{s})^{-1}$ respectively. Given the instability of the secondary organic tracers caused by the oxidations, the uncertainty of the tracer-based method due to the ozone oxidations of secondary organic tracers was also addressed.

Keywords: secondary organic tracer, smog chamber experiment, rate constant, heterogeneous oxidation, tracer-based method, uncertainty

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Characterization of VOCs, PAHs and CDD/CDFs from Gas Flaring at Different Liquid Injection Conditions

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Abstract:

Organic compounds (OC) emitted from gas flaring could potentially be a concern for human health and climate. Little research to date has described and quantified the OC emissions from gas flaring in detail. Therefore, this study provides comprehensive characterization of the OC, including volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs) and chlorinated dibenzodioxins/dibenzofurans (PCDD/Fs) from gas flaring utilizing different analytical techniques.

A pilot-scale co-flow diffusion flame burner was employed to mimic flaring by burning three methane-based fuel surrogates, which approximates the range of concentrations of hydrocarbon and inert gases typically found in Alberta. To investigate the effects of potential aerosol carry-over of non-hydrocarbon liquids found in the produced water on well-completion flares; distilled water, Cardium flowback water surrogate, flowback water collected from the Duvernay, and a 15% NaCl solution were aerosolized and introduced into the flare at varying liquid flowrates. The resulting OC emission profiles were analyzed and compared with those without liquid injection. Canisters, quartz, and PUF filters were used to collect the VOCs, PAHs, and PCDD/Fs, which were subsequently analyzed via gas chromatography/mass spectrometry techniques. Additionally, a photoacoustic technique was exploited to measure the soot emissions.

The analytical results illustrated that fuel types investigated had relatively small effect on the target OC emissions. However, heavier fuels did produce larger quantities of soot. Alternately, liquid injection was the dominant factor influencing VOCs, PAHs and PCDD/Fs emitted from the flare, with the NaCl solution causing the highest concentrations. Moreover, Cl⁻ variation at different flowrates of liquid injection were further investigated and high Cl⁻ content generally caused greater VOCs and PAHs, with the exception of the Duvernay flowback liquid which had relatively low OC emissions.

Field study of secondary organic aerosols using Chemical ionization mass spectrometry

Chenshuo Ye

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Abstract:

Field study of secondary organic aerosols using Chemical ionization mass spectrometry

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Haze pollution is one of the most serious environmental problems in China, influencing both human health and regional air quality. Secondary organic compounds play a central role in particle formation. Oxidation products of volatile organic compounds (VOCs) span a large range of volatility, that affect the partitioning between gas phase and particle phase.

Chemical ionization mass spectrometry (CIMS) has been increasingly utilized in online detection of gas species. Iodide is found to be an efficient reagent ion for ionization of oxygenated organic compounds, most of which are semi- and low- volatile. The filter inlet for gases and aerosols (FIGAERO) installed before the ion-molecular reaction chamber of CIMS allows measurement of organic compounds in particles.

A FIGAERO-I-CIMS was deployed at an urban site in Guangzhou in September-November of 2018 along with other advanced online instruments. Both ozone pollution and haze pollution were observed during the campaign. We detected a number of oxidation products of isoprene and monoterpenes under different pollution conditions. Oxidation products from anthropogenic VOCs were also observed. For example, high concentrations of nitrated phenols indicate reactive oxidation of aromatics in the atmosphere. More oxidized products with higher O/C ratios and lower volatility partition into aerosol, contributing to secondary formation of PM_{2.5} in Guangzhou. Besides, a suite of nocturnal reactive nitrogen oxides including ClNO₂ and N₂O₅ are commonly observed, demonstrating strong NO_x chemistry at polluted nights.

Impacts of SO₂, Relative Humidity, and Seed Acidity on Secondary Organic Aerosol Formation and Chemical Composition in the Ozonolysis of Butyl Vinyl Ether

Peng Zhang

Rcees

Tianzeng Chen, Rcees

Abstract:

Alkyl vinyl ethers are widely used as fuel additives, while their atmospheric chemistry and potential contribution to secondary organic aerosol are still not well known under complex pollution condition. In this work, we examined the impact of SO₂, relative humidity (RH), and particle acidity on the formation and oxidation state (OSc) of SOA from butyl vinyl ether (BVE) ozonolysis. Increasing SO₂ concentration produced a notable promotion to SOA formation and OSc due to the significant increase in H₂SO₄ particles and the formation of higher oxidized components. Over the RH range 1%–55%, both the formation and OSc of SOA, along with SO₂ consumption, exhibited the similar change at different RH range. The promotion and inhibition effect of RH on the formation and OSc of SOA observed at different RH range highlight the importance of competition between H₂O and SO₂ reactions with stabilized Criegee intermediate (sCI) in BVE ozonolysis at the ambient RH. In addition, particle acidity mainly contributed to the change in chemical composition of SOA but not SOA formation. Results presented here extend the previous analysis of BVE-derived SOA and further aid in understanding the contribution of BVE ozonolysis to atmospheric SOA under highly complex pollution conditions.

Removal of HMDS and Acetone with Zeolite-Molecular sieve composite material

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Hao-Wei Huang, Yi-Ren Chiu, Joy Thomas and Chang-Tang Chang

Abstract:

Semiconductor industry often discharges VOCs which comprises of high concentrations of HMDS (Hexamethyldisilazane) and acetone. Thermal decomposition of the HMDS results in deactivation of the catalyst activity of solid silica and therefore requires pretreatment to separate HMDS from VOCs. HMDS contains Si components in high temperature incineration and generates silicon dioxide powder. It is noteworthy that if RTO (Regenerative Thermal Oxider) was used as the final incineration system without removing HMDS, the generated silica powder would shutdown the RTO of the thermal storage material. As a result, the pressure loss would be increased and the function of RTO will be failed. Therefore, the aim of this research is to develop a novel selective adsorbent to remove HMDS from flue gas before entering catalyst reaction.

Domestic and foreign research shows adsorption treatment is the best method to remove HMDS. The granulated mixture of 4A molecular sieve (M) and zeolite (Z) with different proportion was used to assess the adsorption performance. The adsorption experiments were carried out at room temperature under different acetone and HMDS concentration, material dose and gas flow rate.

The results show that the adsorption capacity of HMDS was decreased with increasing the ratio of molecular sieve. This concludes that component of zeolite in the ratio is more influential than molecular sieve. The adsorption capacity of HMDS is ranged from 0.5 to 1.2 mg/g-1. The adsorption of HMDS is suitable by using the composite of M and Z with the ratio as 2:3.

Keywords: VOCs, HMDS, Zeolite.

Abundance and Sources of Benzo[a]pyrene and Other PAHs in Ambient Air in Hong Kong: A Review of Measurements from 1997 to 2016

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Jian Zhen YU, Chemistry Department, the Hong Kong University of Science and Technology

Abstract:

Many compounds in the polycyclic aromatic hydrocarbons (PAHs) family are of environmental concern due to their toxicity, carcinogenicity and mutagenicity, prompting the need of monitoring their long-term trends and research on their potential sources. Three air monitoring programs in Hong Kong report concentrations of ambient PAHs, namely (1) respirable suspending particle (RSP) speciation program that monitored benzo[a]pyrene (BaP) from January 1997 to March 2000, (2) total suspending particle (TSP) speciation program that monitored BaP from January 1997 to December 1999, and (3) the toxic air pollutant (TAP) monitoring program monitoring BaP and 16 other PAHs in the combined gas and particulate at two general urban stations (denoted TW and CW) since January 1998. In this work, we review all the available PAH measurements in Hong Kong in the above three monitoring programs, with emphasis on the temporal trends of BaP and the other 16 PAHs in the past 19 years. Both correlation matrix and principal component analysis (PCA) show that those PAHs sharing similar structures exhibit highly correlated relationships as well as virtually identical long-term trends. Almost every measured PAH's concentration in Hong Kong exhibits a decline trend since 1998, with a statistically significant Sen's slope. For instance, BaP has been reduced by 79% at TW site and 77% at CW station from 1998 to 2016, with a Sen's slope of -0.016 and -0.011 ng/m³/year, respectively. The correlation of BaP with some major species in RSP and three diagnostic ratios of PAHs are employed to explore the source origins of PAHs in Hong Kong. The above analysis reveals that PAHs mainly come from a combination of vehicular emission and biomass/coal combustion. The decline trend of PAHs is consistent with the declined particulate matter emissions from vehicular exhaust and biomass/coal combustion, as indicated by their respective source tracers. This study fills the data vacancy in the long-term trends of ambient PAHs for the Pearl River Delta region.

Purposefully Optimization of TiO₂ Photocatalysts for the Elimination of Typical VOCs

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Abstract:

The elimination of SOA precursors such as NO_x, NH₃ and VOCs by photocatalytic degradation has been proven to be a promising way in inhibiting the formation of secondary organic aerosols. The adsorption and degradation of a particular kind of VOCs on the surface of TiO₂ surface relies on its molecular structure and polarity. The fact that multiple gaseous pollutants coexist under actual practical conditions raised new questions in understanding the role of TiO₂ photocatalysts in air purification. On one hand, as the active sites on TiO₂ surface are limited, competitive adsorption would happen between different gas molecules, which may hinder the degradation of target molecules or even lead to the deactivation of photocatalysts. On the other hand, reactions may happen between active radicals and mid-products formed during the degradation of different gas molecules and influence their photocatalytic degradation processes. Understanding the differences and interactions between different VOCs during the photocatalytic degradation process would shed light on the further optimization of TiO₂ photocatalysts, which is essential for its application in the air purification industry.

Herein, the impacts of the surface properties of photocatalysts on the adsorption and degradation of different gas molecules will be discussed. Coupling TiO₂ with carbon nanostructures would influence the adsorption of gas molecules and the generation of ·O₂⁻ and ·OH radicals due to the altered affinity for O₂ and H₂O. RGO-TiO₂ showed strong affinity for non-polar molecules and enhanced generation ratio of ·OH radicals, which made it a more suitable photocatalyst for the elimination of o-xylene and ethylene than TiO₂. Interestingly, further doping rGO with N atoms to form N-rGO-TiO₂ would promote the adsorption and degradation efficiency for polar molecules like acetaldehyde. These results enabled the purposefully design and optimization of TiO₂ photocatalysts for the elimination of target VOCs. The competition or synergistic effects during the photocatalytic degradation of mixed gases will also be discussed.

Process-specific emission characteristics of volatile organic compounds (VOCs) from petrochemical industry in Shandong

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Abstract:

In order to study the process-specific emission characteristics of volatile organic compounds (VOCs) from petrochemical industry, large number of source samples were collected from three typical enterprises A, B and C in Shandong. Enterprise A was mainly based on petroleum refining, gasoline storage tank leakage and catalytic reforming discharge had the highest concentration of VOCs; for gasoline tank leaks, toluene, isopentane, n-Pentane, m/p-xylene and n-butane were the top five VOCs detected; for catalytic reforming discharge, the five most abundant species were

n-decane, ethylene, toluene, isopentane and acetylene. Enterprise B mainly produced methyl ethyl ketone, the production unit emitted the most VOCs, including 1-butene, isobutane, cyclopentane, n-butane and isobutane. Enterprise C mainly produced styrene, the loading platform emitted the most VOCs, including benzene, styrene, ethylene, 1-butene and propene. Understanding the VOC emission components of the various processes in the petrochemical industry is important for developing targeted VOCs reduction strategies.

Chemical speciation distribution and risk assessment of heavy metals in PM_{2.5} during winter and summer in Xi'an

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Abstract:

Atmospheric heavy metal pollution is an important environmental problem in China. This study took Xi'an, an important central city in Western China, as an example. 46 daily PM_{2.5} samples were collected from December 2015 to February 2016 (winter) and June to August 2016 (summer) in Xi'an. Using a modified BCR method to evaluate the chemical speciation distribution of heavy metals in PM_{2.5}, and their health risks were conducted by the US EPA method. Sources were identified by enrichment factor (EF), cluster analysis and principal component analysis. Results indicated that the average mass concentration of heavy metals in summer and winter was 23.2 $\mu\text{g m}^{-3}$ and 76.6 $\mu\text{g m}^{-3}$, respectively. The EF of As, Cd and Cr exceeded 100. Principal component analysis and cluster analysis showed that metal smelting and coal burning, motor vehicle exhaust, industrial emissions are the main sources of heavy metals, contributing by 44.1%, 21.3% and 14.8%, respectively. The concentration of heavy metals was followed by Al ($3180.6 \pm 679.0 \text{ ng m}^{-3}$) > Cr ($342.6 \pm 76.7 \text{ ng m}^{-3}$) > Zn ($267.1 \pm 74.4 \text{ ng m}^{-3}$) > As ($117.2 \pm 18.6 \text{ ng m}^{-3}$) > Pb ($35.0 \pm 20.9 \text{ ng m}^{-3}$) > Cd ($16.3 \pm 6.0 \text{ ng m}^{-3}$) > Ni ($11.3 \pm 5.0 \text{ ng m}^{-3}$). More than 50% of Cd was found bound to water soluble and exchangeable fraction, most of Pb, Ni and Zn were distributed in carbonate and organic matter fraction, and most of Al, As and Cr were distributed in residual fraction. The bioavailability Index (BI) of Cd, Ni and Pb were in high level, and it showed a slightly higher trend in winter than in summer, which should be focused. During the sampling period, the non-carcinogenic risks raised by heavy elements in PM_{2.5} through inhalation pathway are less than 1, at an acceptable level. The cancer risk of As and Cr were exceed the threshold range ($10^{-6} \sim 10^{-4}$), which was 5.3×10^{-6} and 4.3×10^{-5} , respectively.

Key words: heavy metals, PM_{2.5}, chemical speciation, bioavailability, risk assessment

Comparison of chemical properties of emission from a diesel engine by using 10% biodiesel fuel (B10) and petroleum diesel fuel under transient cycle mode -2nd Report-

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Abstract:

Biodiesel is one of alternative fuels as renewable, carbon neutral and biodegradable for compression ignition (CI) engines. In this study, using 10% Rapeseed Methyl Ester (RME) biofuel blended biodiesel fuel and petroleum diesel fuel, the impact of regulated emission components CO, THC, NOX, and unregulated emission components, EC, OC and PAHs were investigated. Our study have used modern diesel engine under three conditions, engine-out, tailpipe-out, and catalyzed diesel particulate filter active regeneration conditions. The engine met to Japan Post New Long Term emission regulation was equipped with after-treatment systems comprised of diesel oxidation catalyst (DOC) and catalyzed diesel particulate filter (c-DPF). All conditions were conducted on the Japanese JE05 test cycles.

The results indicated that there was no significant impact on regulated emissions of CO, THC, NOX in the all sampling conditions. On the other hand, there were some effects of elemental carbon (EC), organic carbon (OC) and polycyclic aromatic hydrocarbons (PAHs) as unregulated emissions. Emission of EC2 as elemental carbon for 10% RME biodiesel was significantly lower than case of petroleum diesel (D) fuel under engine-out and tailpipe-out condition, but increased was observed under regeneration condition due to larger fuel consumption compared to D fuel used. Particle-phase PAHs also increase on the regeneration condition using 10% RME fuel. Since the 10% RME biodiesel fuel has lower calorific value than the D fuel, so, it was observed to need longer period of regeneration compared to using D fuel.

In addition, OC1 and PAHs emission using 10% RME fuel per fuel consumption under DPF regeneration condition were also higher than D fuel. The reason for this is considered to be that combustibility deterioration by poor volatility of 10% RME fuel.

It is expected that the mixing ratio of biofuel to D fuel will increase mainly in Asia in the future, but it is considered important to grasp the behavior of such detailed components.

PM_{2.5}-bound carbons emitted from a diesel-generator fueled with WCO-biodiesels

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Abstract:

In addition to causing air pollution and endangering human health, diesel exhaust particles (DEPs) are also one of the main sources of PM_{2.5} in many countries. Moreover, DEPs mainly consist of carbon particles, ash, SOFs (soluble organic fractions) and sulfur-containing compounds. Those carbon particles are chiefly formed by the combustion of an excess of fuel and are mostly in the form of solid carbon. Therefore, this study investigates the emission characteristics of PM_{2.5} and three fractions (entire (E), acid-rain (A), and water-soluble (W)) of PM_{2.5}-bound carbons by utilizing several diesel and waste cooking oil-based biodiesel (WCO-Biodiesel) blends as the fuels of a diesel engine generator. The diesel-WCO-Biodiesel blends were prepared by adding 20% and 40% of waste cooking oil-based biodiesel into to fossil diesel to form W20 and W40, respectively, and they were used as fuels in a diesel fuel engine generator operated at 1.5 and 3.0 kW loads. The results show that the concentrations of carbonaceous contents in the engine emission PM_{2.5} were in the order E-TC (15.3 mg/Nm³ in average) > A-TC (7.14 mg/Nm³ in average) > W-TC (5.92 mg/Nm³) when using W0 (pure diesel), W20, and W40. The E-TC accounted for 88.2% of PM_{2.5} mass emission, while the E-EC content was 2.97 time that of E-OC. In comparison with using W0, the mass concentrations of PM_{2.5} and PM_{2.5}-bound E-TC、E-OC, and E-EC could be reduced when using W20 and W40. The highest reduction of PM_{2.5} (23.5%) was achieved by using W20, while the reduction was better for E-OC (31.2% in average) than for E-EC (12.8% in average). This study shows that using W20 and W40 could reduce the emissions of PM_{2.5}-bound E-TC, A-TC, and W-TC from the generator. The entire fraction (E) was the highest among the three fractions for all the TC, EC, and OC measurements.

Hazardous Air Pollutants in Fine Particulate Matters: Source Apportionment and Exposure Risk Assessment at Different Areas in Taiwan

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Abstract:

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are semi-volatile pollutants and listed as priority pollutants by European Food Safety Authority (EFSA) and California Air Resources Board (CARB), some PAHs also have been identified as carcinogenic and mutagenic by International Agency for Research on Cancer (IARC). PAHs are primarily generated during the incomplete combustion of organic materials (e.g. coal, oil, petrol, and wood). Main sources from anthropogenic activities of PAHs are traffic, fire-power plant, residential and industrial emissions in urban areas.

Materials and methods

In this study, the sampling sites were selected in northern, central, and eastern air quality areas (including 6 industrial stations, 3 urban stations, 3 suburban stations and 1 background site) in Taiwan. In addition, the sampling sites in the vicinity of tunnels and fire power plant (3 fire power plants and 1 tunnel) were also evaluated. We investigated the composition and concentration variation of PAHs in the vicinity of the possible emission source, and estimate the emission coefficient of motor vehicles. Moreover, applying the principal component factor method (PCA) and characteristic ratio (DR) positive matrix factor method (PMF), the possible sources of PAHs were studied.

Results and discussion

The concentration of PM_{2.5}-bound PAHs in atmospheric is significantly higher in industrial (0.246~4.17 ng/m³) and tunnel (1.32~4.36 ng/m³) stations than in urban (0.182~0.402 ng/m³) and rural (0.180~0.217 ng/m³). Urban and rural stations are more affected by mobile sources, while the toxic

equivalent BaP_{eq} concentration is also significantly higher in industrial and tunnel stations than in urban. The results of PCA analysis also showed that sampling sites were associated with fossil fuel combustion, industrial sites were affected by stationary sources emission, urban and rural sites were affected by mixed pollution of stationary and mobile emission sources. DR analysis results showed that the sampling sites were related to liquid fossil fuel combustion of stationary and mobile emission sources. The results of PMF analysis showed that 21.8% atmospheric PAHs was provided by traffic emissions (especially for gasoline engine vehicles) ($r = 0.50$), 16.8% by cogeneration power plants in southern Taiwan ($r = 0.89$), 24.9% by coal-fired power plants in northern Taiwan ($r = 0.84$), 36.6% by coal-fired power plants in central Taiwan ($r = 0.98$).

Influence of the Fuel and Engine on Secondary Aerosol Formation from Gasoline Vehicular Emissions in China

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Abstract:

Vehicular gas emissions are considered as the major precursor to urban secondary organic aerosols (SOA). The formation potential is highly dependent on the fuel quality and the type of engines. Here we conducted experiments to mimic SOA formation from gasoline vehicle emissions. Historically, the China fleet has been dominated by vehicles equipped with port-fuel injected (PFI), but the market share of vehicles equipped with gasoline direct injection engines (GDI) has increased dramatically. And 10% of renewable energy ethanol (E10) may be added to the gasoline of China market in the future. Thus, in this study, we focus on the influence of ethanol content (0% or 10%), engine types (GDI or PFI) and different engine loads (idling or constant velocity) to the SOA formation potential from gasoline motor cars emissions. We exposed the diluted emissions to a range of oxidation (O₃ and OH) concentrations in the Go-PAM, resulting in different OH exposures. We observed variations of different cases in SOA formation.

Our results showed that compared to PFI engine, the exhaust of GDI engine at idling has larger SOA formation potential. The highest SOA production of PFI engine at idling occurred after 3.6 days of equivalent atmospheric oxidation. Comparing to the PFI engine, the peak SOA production occurred at higher OH exposure for GDI engine. Besides, SOA production potential are about 2 times larger when using E10 than using common used gasoline in China as energy in PFI engine at idling. OA enhancement

is more obvious at idling than that when vehicle was at a constant velocity whatever engine is used. Generally, densities of particles at size of 70nm,140nm and 200nm keep growing up as O₃ concentration increase from about 0ppm to 10ppm.

The results of this study highlight the utility of Go-PAM for studying SOA formation potential from vehicle exhaust, and provide some indications of the influence of ethanol content and different engines to SOA formation in China. Our results suggested that if GDI and E10 gasoline are used for vehicles in the future, they may cause more particle pollution, which should be carefully considered in the future policies.

Characterization of Vehicle Emission Changes in Hong Kong via Tunnel Measurements

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Abstract:

Vehicle emissions were measured in the Shing Mun tunnel (SMT) in Hong Kong during winter 2015. Emission factors (EFs) were compared to the 2003–2004 measurements in the same tunnel to assess emission changes over time. Sulfur dioxide (SO₂) and PM_{2.5} measured in 2015 were only ~20% of those in 2003–2004, indicating the effectiveness of vehicle emission controls in reducing these pollutants. While the total measured volatile organic compounds (VOCs) emission factors were ~44% lower, the marker species for liquefied petroleum gas (LPG; e.g., n-butane and isobutene) increased in 2015, likely due to the increased LPG fleet. The difference between the 2003–2004 and 2015 emission factors were not statistically significant for carbon monoxide (CO), ammonia (NH₃), nitrogen oxide (NO), and nitrogen dioxide (NO₂). Tunnel NO₂ concentrations and NO₂-to-nitrogen oxides (NO_x) ratios increased, indicating an increased NO₂ fraction in the primary vehicle exhaust emissions. The contribution of geological materials to PM_{2.5} increased from 2% in 2003 to 5% in 2015, signifying the importance of non-tailpipe emissions. The EMFAC-HK mobile source emission model estimates and SMT measurements differed <40% for the 2015 data with EMFAC-HK being lower, while EMFAC-HK estimates were 2-4 times of measured EFs for CO, NO, and VOCs in 2003. Source apportionment of the tunnel PM_{2.5} suggests the dominance of diesel engine exhausts, followed by secondary sulfate and nitrate, gasoline engine exhausts, and road dust.

A separation of the impact of coal-fired power plant emissions on the surface air pollution

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Abstract:

Although power plants are commonly recognized as one of the largest emission sources, the impacts of power plants have not been studied in detail. Generally, power plant is located on coastal area, and had characteristics that the emitted air pollutant from stack of power plant rise to effective stack height before starting to disperse. Therefore, various meteorological factors, especially wind vector at effective stack height and internal boundary layer height, must be considered. The impact of power plant air pollutant emissions on the surface air pollution is investigated based on statistical analyses of various data such as meteorological data, surface air pollution data and telemonitoring system (TMS) data. In this study, to separate the effect of power plant emissions on the air pollutions in the Seoul Metropolitan Area (SMA) in Korea for the period of 2014-2017, Kolmogorov-Zurbenko filter (KZ filter) and empirical orthogonal function (EOF) analysis were applied to surface air pollution data, PM10, SO₂ and NO₂. Before that, we classified the data according to meteorological conditions, such as wind direction and wind speed, that the power plant emissions were able to affect the surface air pollution. Each time series of EOF mode was compared with that of power plant emissions. As a result, statistically significant correlation was obtained between TSP emissions from Dangjin power plant and EOF mode 2 of surface PM10 concentration. Furthermore, EOF mode 3 of surface NO₂ and EOF mode 4 of surface SO₂ were also correlated with NO₂ and SO₂ emissions. These results were able to obtained when the surface air pollution data were classified in consideration of meteorological conditions. Meteorological characteristics of the region will important to determine the impact of power plant emission on the surface air pollution.

Determination of the size-dependent emission rate equation of nanoparticles generated from commercial cooking oil heating

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Inha University

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Abstract:

Many studies have shown that nanoparticles are harmful to humans that cause respiratory diseases and disorders, and cooking is one of the major factors that generates nanoparticles indoors. The amount of particles generated during the cooking processes depends on cooking conditions such as food type, the heating temperature, and the area of surface heating. Among the indicators that quantify the amount of particles emitted by cooking, the emission rate is generally used, which is obtained by dividing total emissions amount by the measurement time. However, it is not sufficient to accurately grasp the particle emission characteristics, since the emission rate does not take into account the time- and temperature-dependent feature. For these reason, we have devised a new emission rate equation for each size of nanoparticles considering time and temperature change. Experiments were performed using four different kinds of commercial cooking oils. ELPI+ (Electrical Low Pressure Impactor) was used to measure the concentration of nanoparticles in real time. The oil was heated up close to 200 degrees Celsius by continuously supplying a constant calorific value. Most of the particles produced by oil heating were smaller than 1 μ m in terms of number concentration. As the temperature increased, the concentration of the particles in most of the particle sizes increased proportionally. However, particles with small diameters increased more rapidly than particles with large diameters, which increased the concentration ratio of small diameter particles among the whole particles.

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Display Date and Time: 09:15, 28 May 2019 (Tuesday) – 17:30, 29 May 2019 (Wednesday)

Authors in Attendance Date & Time: 15:30-17:30, 29 May 2019 (Wednesday)

Poster Venue: Foyer, Wong Cheung Lo Hui Yuet Hall, 6/F, Lau Ming Wai Academic Building, City University of Hong Kong

Session Chair: Keith Ngan, City University of Hong Kong

Special Symposium: Aerosol-water interaction		
Speaker	Title	Poster number
Kazuhiko Miura, Tokyo University of Science	Study on hygroscopic characteristics of PM2.5 in south Kanto, Japan	P2-001
Liya Guo, Chinese Academy of Sciences	A comprehensive study of hygroscopic properties of methanesulfonates	P2-002
Deqiang Zhang	Characteristics of CN and CCN in number concentration in the marine atmosphere along the long coastline of China in the spring of 2018	P2-003
Daizhou Zhang, Prefectural University of Kumamoto	Particles and droplets in and out continental-emission influenced stratocumulus over the Sea of Japan: a case study with electronmicroscopy	P2-004
Wenjun Gu, Chinese Academy of Sciences	Investigation of water adsorption and hygroscopicity of atmospherically relevant particles using a commercial vapor sorption analyzer	P2-005
Xuezhe Xu, Chinese Academy of Sciences	Development of a humidified cavity-enhanced albedometer and its application in aerosol optical hygroscopicity measurement in Guangzhou	P2-006
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Study on hygroscopic characteristics of PM_{2.5} in south Kanto, Japan

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Abstract:

The hygroscopic characteristics of atmospheric aerosol were observed using optical particle counters (OPC). We measured the volume concentration ($V_{0.3-2.0}$) of diameter 0.3 - 2.0 μm close to PM_{2.5} at inland (Noda City) and coastal (Koto Ward) sites located in the southern part of the Kanto Plain. Chemical compositions of PM_{2.5} were obtained by an ion chromatography method. Observations began in Noda City on November 1, 2016 and began in Koto Ward on December 5, 2016. To measure the hygroscopic growth of the aerosol, $V_{0.3-2.0}$ were obtained under the following two observation conditions; one was dry and ambient (without drying) conditions, and the other was dry and wet conditions. Hygroscopic growth parameters (κ) were obtained based on the volume growth rate calculated from OPC and compared with those calculated from the chemical compositions and meteorological data.

As a result, the values of κ in Noda City in summer and winter was 0.175 and 0.308, respectively, and the values of κ in Koto Ward in summer and winter was 0.224 and 0.325, respectively. The values of κ calculated from chemical compositions were not seasonally fluctuated if we assumed constant value of κ for organics throughout the year. It has been reported that the value of κ of organic carbon is on average 0.1 in the summer and 0.3 in the winter (Snider et al. 2016). The fraction of water soluble organic carbon among organic matters in PM_{2.5} was low in summer and high in winter at the observation sites, indicating that κ value for organics was lower during summer than winter. This may affect the seasonal fluctuation of the OPC derived κ values. Furthermore, recent study has reported that nitrate salt particles mixed with oxalic or succinic acid have enhanced hygroscopic growth at high RH due to water uptake by dissolved fractions of the organic acids (Jing et al. 2018). It is suggested that

information about the organic species in PM_{2.5} is essential to reproduce κ values based on the chemical compositions.

References

Snider et al., *Atmos.Chem.Phys.*,16, 9629-9653, 2016

Jing et al., *Atmos. Chem. Phys.*, 18, 5115–5127, 2018

A comprehensive study of hygroscopic properties of methanesulfonates

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Abstract:

A comprehensive study of hygroscopic properties of methanesulfonates

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Abstract: Methanesulfonate, an important atmospheric oxidation product of dimethyl sulfide, is ubiquitous in marine aerosols. However, its hygroscopic properties are not well understood. In this work, two complementary techniques were employed to investigate the hygroscopic behaviour of a few methanesulfonates, including $\text{CH}_3\text{SO}_3\text{Na}$, $\text{CH}_3\text{SO}_3\text{K}$, and $(\text{CH}_3\text{SO}_3)_2\text{Ca}$. A vapor sorption analyzer (VSA) was used to determine the change of sample mass with relative humidity (RH) under isotherm conditions, and the deliquescence relative humidities (DRH) for temperature in the range of 5-30 °C as well as water-to-solute ratios (WSR) as a function of RH at 25 °C were reported for these three compounds. For example, DRH and WSR were determined to be ~70% and 19.873 ± 0.2249 at 90% RH for $\text{CH}_3\text{SO}_3\text{Na}$. In addition, a humidity-tandem differential mobility analyzer was used to measure the change in mobility diameter of aerosol particles with RH (up to 90%) at room temperature. For example, $\text{CH}_3\text{SO}_3\text{Na}$ aerosol particles were found to become deliquesced at ~70% RH, consistent with the VSA results, and their hygroscopic growth factor was determined to be 1.48 ± 0.02 at 90% RH.

Characteristics of CN and CCN in number concentration in the marine atmosphere along the long coastline of China in the spring of 2018

Deqiang Zhang

teacher-student relationship

Abstract:

In this study, we employed a suit of instruments including a fast mobility size (FMPS, Tsi), Condensation particle counter (CPC, 3750), Cloud condensation nuclei counter (CCN-100, DMT), SO₂ and NO_x analyzers etc., to measure particle number size distributions, number concentrations of cloud condensation nuclei (CCN) at varying supersaturations and related gases in the marine atmospheres along the long coastline of China in the spring of 2018. Benefit from the high time-resolution measurements of FMPS in one second, we clearly identify the particle and gas signals from ship self-emissions. When the self-emission signals were completely removed, N_{cn} varied from 2.02*10³ cm⁻³ to 5.99*10³ cm⁻³ with the average value of 4.72±1.10*10³ cm⁻³. N_{ccn} at supersaturation(SS) of 0.2%, 0.4% and 1% oscillated around 2.41±0.93*10³ cm⁻³, 2.57±0.93*10³ cm⁻³ and 2.90±0.96*10³ cm⁻³. We further separated the continent-derived air masses from those from remote marine atmospheres based on a multiple of indicators. N_{cn} oscillated around 2.09*10⁴ cm⁻³ in the former air masses, but it largely decreased to 6.96*10³ cm⁻³ in the latter air masses. The similar decreases were also obtained in NCCN, i.e., decrease by 2.83*10³ cm⁻³, 2.67*10³ cm⁻³ and 1.64*10³ cm⁻³ at SS=0.2%, 0.4% and 1%, respectively. We calculated the activation ratio and kappa value of atmospheric particles in these air masses and analyzed their variations. Moreover, we also characterized N_{cn} and N_{ccn} in marine atmospheres. The ratios of N_{cn}/SO₂ were around 4.20±0.42*10³ cm⁻³/ppb except the influence of plumes. The same can be said for N_{ccn} at varying SS.

Particles and droplets in and out continental-emission influenced stratocumulus over the Sea of Japan: a case study with electron microscopy

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Abstract:

Aerosol particles were collected with an aircraft-borne sampler below, within and above stratocumulus clouds over the Sea of Japan on December 3, 2000, when continental influence was expected. Particles in the range of $0.3 \sim 7 \mu\text{m}$ and cloud droplets in the range of $0.3 \sim 10 \mu\text{m}$ were captured and they were identified individually upon their elemental composition and morphologies from the analyses by using electron microscopes and an energy dispersive X-ray spectrometer. Interstitial particles and droplets coexisted in the cloud and their number ratio was about 3:2 in the detected ranges. Spherical particles that were inferred to be mainly composed of sulfate, nitrate, ammonium and possible organics occupied more than 95% of the interstitial particles. Similar particles were also the majorities in the above- and below-cloud air, where their percentages to total particles were 93% and 74%, respectively. Acidic sulfate particles were rarely found in the below-, in- and even above-cloud air. The nuclei of 90% cloud droplets had similar composition and size distribution to the spherical particles in the scope of our analysis. These results suggest that the continentally influenced stratocumulus was characterized by neutralized nuclei and interstitial particles. Sea-salt particles were detected mainly in the below-cloud air. A few droplets with sea-salt nuclei were detected there and in the cloud. Such droplets were usually larger than those with spherical nuclei but their number fraction to total droplets in the cloud (about 8%) was much smaller than the spherical nuclei to total droplet fraction, indicating that sea-salt particles produced larger droplets but they constituted only a small number fraction of droplets in the cloud.

Investigation of water adsorption and hygroscopicity of atmospherically relevant particles using a commercial vapor sorption analyzer

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Abstract:

Investigation of water adsorption and hygroscopicity of atmospherically relevant particles using a commercial vapor sorption analyzer

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Abstract

In this work we developed a method to investigate hygroscopic properties of atmospherically relevant particles for temperature in the range of 5-30 °C, using a commercial vapor sorption analyzer. We measured the deliquescence relative humidities (DRH) of six compounds at different temperatures, and the measured DRH values agreed very well with those reported in literature. In addition, we determined the mass hygroscopic growth factors of (NH₄)₂SO₄ and NaCl as a function of RH at 25 and 5 °C, showing good agreement with those predicted using the E-AIM model. Our systematical characterization suggested that the technique developed in this work was a reliable and robust method to investigate aerosol hygroscopicity. The method was further employed to investigate hygroscopic properties of calcium- and magnesium-containing salts and pollen species, and the results will also be presented.

Development of a humidified cavity-enhanced albedometer and its application in aerosol optical hygroscopicity measurement in Guangzhou

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Abstract:

Hygroscopic aerosols can take up water and they can grow larger in size with increasing ambient relative humidity (RH), which leads to dramatic changes in optical properties (extinction (b_{ext}), scattering (b_{scat}), absorption (b_{abs}) coefficients, and single scattering albedo (SSA)). The enhancement factors of extinction, scattering and absorption coefficients ($f(\text{RH})_{\text{ext,scat,abs}} = b_{\text{ext,scat,abs}}(\text{RH}) / b_{\text{ext,scat,abs}}(\text{dry})$) are key parameters that determining aerosol hygroscopicity, mixing state and aging degree. However, partly due to a lack of capable instrument, hitherto, mostly field studies only focused on the measurement of $f(\text{RH})_{\text{ext}}$ and $f(\text{RH})_{\text{scat}}$, few reports on $f(\text{RH})_{\text{abs}}$ measurement. In this work, a humidified cavity-enhanced albedometer (Wetcea) was developed to directly and simultaneously measure $f(\text{RH})_{\text{scat}}$ and $f(\text{RH})_{\text{abs}}$ at defined RH in the range of 20-90%. The hygroscopic growth curves were also obtained. Ambient aerosol optical hygroscopicity measurement using the developed instrument was carried out at an urban site in the megacity of Guangzhou, China. Detailed characterization of the Wetcea and results of the field observation will be presented.

The impact of the volatility of NH₃ on the hygroscopicity of mixed sodium succinate and ammonium sulfate particles

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Abstract:

The impact of the volatility of NH₃ on the hygroscopicity of mixed sodium succinate and ammonium sulfate particles

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Abstract

Atmospheric aerosol particles, which typically consist of organic and inorganic substances, affect visibility degradation, human health, and global climate through their profound impacts on the earth's radiative balance. As one of the most important physicochemical properties of atmospheric aerosol particles, the hygroscopic properties dependent on the chemical compositions determine the size, concentration, reactivity and phase state of the particles. It was found that hygroscopicity of the mixed oxalic acid/NaCl greatly decreased by the release of HCl. In this work, we try to understand the hygroscopicity of the mixed sodium succinate (SS)/ammonium sulfate (AS) aerosols effected by the release of NH₃. For the mixed SS/AS aerosols from different initial pH of solutions, the reaction between SS and AS are monitored at constant RH by FITR-ATR, which show the depletion of ammonium ions (NH₄⁺) and the conversion of carboxylate salt (COO⁻ group) to carboxylic acid (COOH group). The contents of various species (COO⁻, COOH, NH₄⁺, SO₄²⁻ (formed Na₂SO₄)) and liquid water as a function of reaction time are analyzed in detail in order to understand the complex hygroscopicity of the mixed SS/AS.

Acknowledgment

We thank for financial support from the National Natural Science Foundation of China (91644101 and 91544223).

Characteristics of the cloud condensation nuclei measured in the Tokyo Skytree

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Abstract:

Atmospheric aerosols have direct effects of absorbing and scattering sunlight and cloud adjustment effects. Aerosol particles act as cloud condensation nuclei (CCN), and affect climate by changing optical properties and lifetime of clouds. Whether the aerosol particles can be CCN is determined by the surrounding supersaturation degree, the dry particle size, and chemical composition (hygroscopicity) of the particles. In general, the greater the supersaturation degree of the surroundings, the size of dry particles, and hygroscopicity of particles, the more the particles tend to be CCN. To understand aerosol-cloud interaction, it is necessary to observe CCN in various areas since those properties have temporal and spatial variation.

There are a few reports on CCN measurement in the urban sites in Japan. Since the Tokyo Skytree (TST, 35.710°N, 139.810°E, 461 m a.s.l.) is the highest tower in Japan (Tokyo), we can observe continuously urban atmospheric aerosol for a long time at high altitude. In this study, we measured aerosol number size distribution, condensation nuclei (CN) number concentrations, and CCN number concentrations with four different supersaturation degrees at TST, from 21 March to 27 June 2017 (P1), from 27 September 2017 to 12 April 2018 (P2), and from 11 October 2018 until now (P3). We obtained the CCN activity ratio, the critical diameter (D_c) and the hygroscopicity parameter κ from those observation data.

As a result, during P1 and P2, there were two specific points. First, the activity ratio in the daytime (10:00 AM - 12:00 AM (JST)) was lower than that in the nighttime. It was caused by increase of total

aerosol number concentration at small diameter due to human activity. The influence of human activity also appeared in κ . The time when κ was low coincided when the traffic volume increased. Next, although the particle size distribution and D_c of TST were similar to those of Seoul (Julia et al., 2018), TST had fewer aerosol number concentration than Seoul. This tendency was observed during the period when a clean air mass from Pacific Ocean was transported to TST.

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The impact of mineral/dust particles on the formation of summer heavy rainfall in downtown Tokyo, Japan

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Abstract:

The occurrence of urban-induced heavy rainfall (hereafter, UHR) has been observed in many urban areas throughout the world in the previous 50 years. The quantity of UHR can cause severe flood disaster because the rainfall amount can exceed the capacity of sewage systems and drainage canals. Typically, a period of UHR persists for only several tens of minutes from its formation; therefore, there is little time to take measures to minimize the effects of urban flooding damage caused by the extreme rainfall. As UHR is a locally distributed phenomenon, it is very difficult to predict UHR formation based on meteorological analyses using current observation systems and simulation models. Thus, to minimize the damage associated with UHR, it is very important to clarify the formation mechanism of UHR to improve its predictability. The urban heat island (UHI) phenomenon has been considered as a cause of increased summer heavy rain events. We have found that UHR had the highest concentrations of acidic components compared with other types of rain event and suggested that UHIs could accelerate the secondary formation of hygroscopic aerosols. However, these secondary-formed aerosols generally serve as small CCN, making many small cloud droplets that might reduce the overall precipitation efficiency. One possible mechanism for the formation of UHR is the inclusion of giant CCN ($> 2 \mu\text{m}$) such as sea salts at the base of convective clouds containing many smaller droplets formed by secondary aerosols. This process is called warm rain formation. Another possible mechanism for the formation of UHR is ice nucleation, called cold rain formation, which can be divided into homogeneous and heterogeneous ice nucleation. It has long been known that ice crystals will grow preferentially and lead to the rapid formation of precipitable particles under the coexistence of ice crystals and supercooled droplets within a cloud. Mineral dust aerosols can play important roles in heterogeneous freezing by acting as effective IN. The satellite observations, in-situ measurements, and simulation has suggested that mineral dust acting as IN might suppress precipitation. When dust particles are active as both giant CCN and effective IN, continental clouds become wider. After evaporation of cloud droplets, the remaining sulfate-coated coarse dust particles can serve as giant CCN. However, the contribution of dust particles to the formation of sudden and locally distributed heavy rain in urban areas remains uncertain.

The objective of this study was to investigate the impact on UHR formation of airborne dust particles, probably dispersed from paved roads and building rooftops in urban areas by the strong updrafts associated with daytime UHIs in summer. Trace metal elements within the UHR were examined to derive information on the IN, e.g., mineral/road dust particles, although major inorganic ions such as sulfate, nitrate, and sodium ions provided information on the CCN. Here, we report the concentration distributions of soluble and insoluble forms of trace metals, their wet deposition fluxes, and the relationships of their fractions with the oxygen isotope in UHR in comparison with other types of rain event.

Humidity-dependent phase state of SOA particles formed from the oxidation of gasoline vehicle emissions

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Abstract:

The particle phase state is a key factor for determining gas-particle equilibrium, particle reactive gas uptake, mass transport and multiphase chemical reactions, with associated links to secondary aerosol formation. In this study, the relative humidity (RH)-dependent particle phase state of secondary organic aerosols (SOA) formed from dilute gasoline vehicle exhausts was investigated by measuring particle rebound fraction f during the chassis dynamometer testing. The measured SOA were generated by a potential aerosol mass (PAM) oxidation flow reactor using variable O₃ concentrations, over ranges from hours to days equivalent atmospheric aging. The precursors were vehicle exhausts with fuels of either gasoline #92 or gasohol. The chemical compositions and f of SOA were detected by an aerosol mass spectrometers (ACSM) and three-arm impactor coupled with condensation particle counter, respectively. It was found that the particles remain rebounding when the RH was under 40%, but changed to adhere when the RH increased, suggesting a transition from solid to liquid state. Most of the primarily emitted organic aerosols from gasoline vehicle emissions and SOA produced from dilute exhausts were in solid state when RH was below 40%, while the phase transition of SOA produced from vehicles using gasoline #92 and gasohol had different sensitivity to RH. The RH at which SOA produced from vehicle exhausts with gasohol transformed from solid to liquid was about 50%, which was lower than that of SOA produced with gasoline #92 (RH=60%). The phase state conversion of SOA particles formed from gasoline combustion may influence the aging process and multiphase reactions of the particles. The results will provide effective guidance for the implementation of gasohol in urban areas

with different RH background, which plays an important role both in local and regional pollution and human health.

A long-term observational study of chemical characteristics of aerosols and cloud condensation nuclei activities at a coastal site of northern Taiwan, East Asia

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Abstract:

A long-term observational study of chemical characteristics of aerosols and cloud condensation nuclei activities at a coastal site of northern Taiwan, East Asia

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Long-term measurements of hygroscopic properties of atmospheric aerosols are limited although cloud condensation nuclei (CCN) activities have known to vary significantly depending on pollution characteristics and environmental settings. A one-year field measurement study of chemical characteristics of aerosols and CCN activities was conducted at a coastal site of northern Taiwan, situated at the downwind region of Asian continental outflow pollution, during the period of April 2017 to March 2018. Seasonal and diurnal variations of CCN and particle number concentrations showed that significant number of CCN and particles were observed in spring and summer seasons, during which newly formed particles attributed by new particle formation process subsequently grew and acted as CCN in the warmer seasons. Variations of kappa values were suggested to be altered by pollution sources such as aged pollution by long-range transport, and fresh particles produced by new particle formation process. By using cluster analysis of air mass trajectories, five air mass clusters were identified. Aerosols associated with Asian continental outflow pollution were found to have higher kappa values than the those associated with local urban pollution. It was suggested that higher inorganic species in aerosols associated with regional pollution has attributed to the aerosol hygroscopicity. Notably high number concentration of CCN and particles was also found in air masses passing through Taiwan Island, inferring the significant impact of urban pollution sources.

Relative Humidity (RH) History Affects Hygroscopicity of Reactive Mixed Particles of Glyoxal and Ammonium Sulfate or Amino Acids

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Abstract:

Glyoxal (GLY), an abundant and reactive dicarbonyl, can react with a number of reduced nitrogenous species such as ammonium, amines and amino acids in aqueous droplets (1,2,3), thereby affecting the optical (e.g., absorption) or physicochemical (e.g., hygroscopicity) properties of particles (4). Little attention is paid on the effects of relative humidity (RH) history, i.e., the sequence of dehydration (water evaporation) and hydration (water uptake), on these reactive mixed aqueous particles, where reactions can occur more efficiently in concentrated droplets than in dilute ones. In this work, hygroscopicity of levitated single particles of GLY mixed with three types of reduced nitrogenous species, including ammonium sulfate (AS), glycine (GC), and L-alanine (AL), was studied using an electrodynamic balance (EDB). The molar ratio between reduced nitrogenous species and GLY was set at 4:1 by using AS:GLY (2:1), GC:GLY (4:1), and AL:GLY (4:1) mixtures. Two RH sequences were adopted: 1) the introduced droplets were abruptly brought to dry state (RH < 10%) first and then went through a complete deliquescence and efflorescence cycle (D2E); 2) the introduced droplets were brought to the highest RH (>90%) and went through the efflorescence and deliquescence cycle (E2D). Results showed that, compared to nascent AS/GC/AL particles, hygroscopicity of mixed particles was all altered, owing to the formation of either glyoxal oligomers or N-containing organic compounds (1,4). For example, the deliquescence RH of AS was significantly reduced from ~78% to ~53%; the non-hygroscopic (up to 93% RH) AL showed a mass growth factor (MGF) of ~1.3 at 90% RH after mixing with GLY. The most important finding of the current study is that there are different extents of difference between experiments with two RH sequences (D2E vs. E2D): for AS-GLY, the difference is negligible; for GC-GLY, a slightly lower MGF was observed from D2E compared to that from E2D; for AL-GLY, the MGF from E2D (~1.8 at 90% RH) dropped significantly compared to that from D2E (~1.3 at 90% RH). Such results can be explained by the increased hydrophobicity of the three reduced nitrogenous species, whose products with GLY would also show a similar trend of hydrophobicity and affect water uptake ability of the mixed particles after reactions. To conclude, uptake of reactive species such as GLY alters particle

hygroscopicity by forming different products, and such effects depend strongly on RH history for certain mixtures.

KEYWORDS: electrodynamic balance, Ammonium Sulfate, Glyoxal, Glycine, L-Alanine, hygroscopicity

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In situ observation on crystallization behavior of single levitated ternary glycine/NaCl/water microdroplet

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Abstract:

Crystallization behavior of single levitated aqueous microdroplet was investigated using an electrodynamic balance (EDB) equipped with an inkjet droplet generator (IDG). In this study, novel designed slim-type EDB coupled with the microscope was used for the observation of internal crystallization behavior into the levitated droplet with sufficient spatial and time resolutions. With this instrument, we directly observed the crystal growth from the aqueous droplet of glycine and NaCl mixture.

At decreasing ambient relative humidity (RH) of N₂, droplet lose water gradually and a hopping growth of NaCl crystal was immediately occurred from droplet surface in the case of a dry glycine mass fraction of about 0.2. The aqueous droplet contained solid crystal continued to lose water. Subsequently, the crystal growth was stopped and solid inclusion was in equilibrium with the aqueous solution into droplet since droplet weight was stable. This was due to salting-in effect in which salt molecules stabilized glycine molecules by decreasing the electrostatic energy that resulted in increasing the glycine solubility. After that, the high humid N₂ was introduced into EDB in order to dissolve the solid inclusion into aqueous droplet. The droplet began to solidify and then the water of droplet was completely evaporated to generate the solid particle. Further increasing ambient RH, the produced solid particle was perfectly deliquesced to the solution droplet

At a dry glycine weight fraction of about 0.8, the small crystal inclusion was formed without hopping growth into droplet by decreasing ambient RH and polycrystalline shell was formed at droplet surface by increasing ambient RH. This behavior might be enhancement of solution-mediated transformation of two polymorphs of glycine (forms α and γ) by addition of NaCl. Our results showed that the glycine crystallization behavior into levitated droplet was highly complexed in the coexistence of NaCl.

Characterization of Vibrating Mesh Aerosol Generators

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Abstract:

Vibrating mesh nebulizers have been reported to have increased output efficiency, minimal residual volume, and high percentage of particles in the respirable fraction. This work aims to investigate and identify the major operating parameters of vibrating mesh nebulizers and their effects on the characteristics of aerosol output.

Vibrating mesh plates were customarily made to contain 279-4606 tapered holes. The aperture size was uniform on each plate, ranging from 3 to 12 μm . The aperture distance was varied from 75 to 450 μm to investigate the potential of coagulation during droplet generation. The resonance frequency of the piezoelectric was scanned and the aperture plates then vibrated at a fixed frequency (100-300 kHz), causing the ejection of liquid droplets. These nebulizers were mainly evaluated with 0.9% sodium chloride solution. A syringe pump was employed to carry the solution to the vibrating mesh plate. The aerosol output was carried, dried and introduced into the mixing chamber, by dilution air flow of 160 L/min. An aerosol size spectrometer was employed to measure both number concentration and size distribution of aerosol output.

The droplet size was found to increase with increasing aperture diameter. The aperture distance did not affect the number concentration and size distribution of the generated droplets. The droplet size decreased with increasing resonance frequency, but the extent was short of expectation. For each vibrating mesh with different number and size of apertures, there is an optimal vibrating frequency to stably deliver the maximum amount of aerosol output. This maximum feeding rate increased with increasing number of apertures and applied electric current, but the aerosol size distribution remained the same. Fibrous sorbent materials can be used for solution delivery from the reservoir to the vibrating mesh.

Evaluation of Deposition Rate of a Test Chamber for Sheltering in House

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Abstract:

Deposition rate is one of the most critical parameters to evaluate the indoor air quality and exposure dose. This study is started as a result of the Fukushima Daiichi nuclear power plant accident occurred in March 2011, when the radioactive substances with high concentration leaked, to know the effectiveness of sheltering in house during a nuclear emergency. When toxic gases and particles are released, it is not well known the protective effect of sheltering in house during the passing of plume. Therefore, it is crucial to figure out the relationship between "Deposition rate" and "Diameters / the Air Exchange Rate (AER)". In this regard, the deposition rate with the different AER was evaluated experimentally and the comparison of various conditions (well-mixed and no mixing, uncharged and neutralized) under different AER was then performed in this study. The results indicated that the larger the AER is, the easier it is to transport particles of small size, especially the ultrafine particles. In addition, the general rule was presented that the deposition rate is usually less under the well-mixed condition whether the particles are uncharged or neutralized, and neutralized particles are typically greater than uncharged ones whether or not they are well-mixed during being filled into a test chamber. However, some of the results may be affected by the changes in AER or the application of the particle size range. When the AER increased, the deposition rate corresponding to the particle size of less than 40 nm began to tend to zero gradually. Also, when the particle size is greater than 400 nm, this value showed a slight downward trend with the increase of AER.

In this work, the result provides a reference for the effectiveness of sheltering in house and the improvement of indoor air conditions in the event of a hazardous gas release accident. In the future, it will evaluate and simulate the sheltering efficiency in the extreme weather conditions such as haze or dust storm in some countries.

This research was supported by the Nuclear Regulation Authority (NRA) and the Japan Atomic Energy Agency (JAEA).

Characteristic of nanoparticle laden flow and nanoparticle penetration efficiency and deposition pattern on a sharp-bent tube.

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Abstract:

In this study, nanoparticle transport with particle size ranging from 3 to 50 nm through a sharp-bent tube was experimentally investigated under the laminar flow. The fluid flow and particle deposition pattern on the sharp-bent tube were investigated through numerical method. The nanoparticle laden fluid flow on the sharp-bent tube found that the recirculation pattern generated at the corner of the sharp-bent tube and the separated and reattached flow respectively formed at the inner wall right after the bending point. Furthermore, the intensity of the secondary flow was weaker, and the center point of the secondary flow was located farther from the tube wall at lower Reynolds number, so that the nanoparticle residence time on the sharp-bent tube became longer and a smaller number of particles were penetrated through the tube compared to higher Reynolds number. In the experiment, particle size and flow rate were highly affected by the penetration efficiency. Specifically, the smaller particles which had higher diffusion coefficient were more likely deposited on the sharp-bent tube and the higher flow rate which caused the huge difference between the radial- and flow-directional nanoparticle residence time resulted in the increased penetration efficiency. Numerical analysis found that most of nanoparticles were deposited on the outer wall and the discrepancy between the inner and outer wall of deposition rate decreased as Reynolds number increases due to strong mixing effect. Based on the experimental data, empirical correlation fitting curve was determined. The strong diffusion transport rate or weak advection transport rate induced the more particle losses due to secondary flow after bending point, resulting in the decreased relative penetration efficiency.

An Intercomparison of Methods for Determining Mixing State of Particles

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Abstract:

A single particle soot photometer (SP2) was used to measure black carbon (BC) and its mixing state at high temporal resolution and with high accuracy in urban Beijing during the polluted winter of 2018. Time-delay (Δt , or the time of occurrence of the scattering peak minus that of the incandescence peak) is widely accepted to determine whether the particles was internally mixed (coated). We also calculated the coating thicknesses of BC-containing particles on the basis of the leading-edge-only (LEO) fitting method (Gaoetal.,2007) and analyzed the threshold value of shell/core ratios to determine mixing state of particles. Compared with these two methods, both the Δt values and the shell/core ratios can clearly determine whether the particles were coated. However, a histogram analysis of the Δt values in our experiment demonstrated that not every Δt peak resulted from the coating effect and the time-delay method may involve a higher uncertainty when determining a core-shell structure. And, in our study, the negative Δt values where the peak of the incandescence signal occurs before the peak of the scattering signal have been discussed.

Observations of atmospheric particles surface area at several observatories in Japan

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Abstract:

In order to evaluate the influences of atmospheric particles, it is necessary to understand their physical and chemical properties. This study focused on the surface area of particles. The surface area is one of important parameters in the chemical substance adsorptions that occur on the particle surface in the atmosphere. Therefore, the increasing of the particle surface area was suggested more adverse effects on the human health by increasing the amount of the adsorbed chemical substances (Oberdörster et al., *Environ. Health Perspect.*, 2005). Furthermore, the concentrations of the atmospheric particle surface area are focused as a new toxicity index on the human health (Maynard and Maynard, *Atmos. Environ.*, 2002). However, the atmospheric particles surface area has been remained in an uncertain understanding because general observations of the atmospheric particle surface area were limited the calculated surface area assuming a sphere from the observed particle size distributions.

In this study, we automatically and continuously measured the particle surface area by a nano particle surface area monitor (NSAM, Model 3550, TSI) which obtains the particle surface area by measuring the charging amount of the particles charged with counter-flow diffusion charging. We carried out field

observations at Fukue (2017/4/9~2017/5/9), Fukuoka (2018/2/21 ~ 2018/6/1), Noto peninsula (2018/10/12 ~), and Yokohama (2018/10/16 ~) in Japan. This study was investigated the regional features of the particle surface area at each location and the dominant factors of those fluctuations by comparing with the physical and chemical properties observed in parallel.

The observed averaged concentrations of the particles surface area were $94.4 \mu\text{m}^2/\text{cm}^3$, $50.4 \mu\text{m}^2/\text{cm}^3$, and $9.72 \mu\text{m}^2/\text{cm}^3$ at Fukue, Fukuoka and Noto, respectively. Note that the observed season for these measurements was different. Compared with the observation at Fukuoka, the variations of the surface area concentrations in Fukue showed a high correlation with that of PM_{2.5} concentration. The observation at Fukuoka was shown that this concentration tended to increase in the morning and evening. The observation at Fukue which is a depopulated area indicated to increase the particle surface area concentration in only evening. The differences of trends in these observation sites were suggested to depend on higher concentration of black carbon particle due to road traffic in urban area such as Fukuoka. Comparing the surface area obtained by NSAM with the surface area calculated from the particle size distribution measured by Scanning Mobility Particle Sizer spectrometer (SMPS), furthermore, the particles with high surface area were observed when ultrafine particles were observed with high concentrations at Noto and Fukue. Furthermore, we will report the dominant factors of the surface area variations based on the chemical components of the observed particles.

Evolution of sulfate aerosol size distribution in flue gas by external regulation

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Abstract:

Keywords: sulfate aerosol; size distribution; aerosol growth; heterogeneous nucleation

The presence of SO₃ in the coal-fired flue gas could lead to homogeneous nucleation of sulfuric acid aerosol under supersaturated environment. Due to its high number concentration (~108/cm³) and small particle size (< 0.1 μm), it is a challenge to remove sulfuric acid aerosols efficiently by existing methods such as wet electrostatic precipitators and mist eliminators. Moreover, NH₃ escaping from selective catalytic reduction (SCR) can form sulfate aerosols together with SO₃ in high-humidity flue gas. It is believed that increasing particle size can effectively improve the removal efficiency of fine particle. However, there are few studies on enhancing growth of sulfate aerosols so far. Therefore, it is of significantly importance to explore evolution of sulfate aerosol size distribution by external factors, which can develop an effective method to realise the rapid growth.

In this paper, evolution of sulfate aerosol size distribution is studied based on aerosol growth system. The results demonstrate that the number size distribution of sulfuric acid aerosol possesses a unimodal structure with peak at 0.05 μm. When the molar ratio of SO₃/NH₃ between 0.3-1.0, the number concentration of aerosols decreases sharply and the peak of size distribution increases to 0.06 μm. It is due to that sulfate aerosols act as condensation nuclei and are responsible for immediate heterogeneous nucleation. Thus, some unreacted sulfuric acid can adhere to sulfate aerosols which consequently become larger. Cooling flue gas can promote the growth of sulfate aerosols due to heterogeneous condensation under supersaturated environment. When the temperature decreases from 45°C to 30°C, the number median diameter increases by 60%. Corona discharge has significant effect on aerosol size distribution. On the one hand, the dielectrophoresis nucleation of the vapor on electrically charged centers enhances the condensation of water vapor, which accelerates the growth of sulfate aerosols. On the other hand, electrical forces affect relative motion between charged aerosols, which promotes the agglomeration of sulfate aerosols. When electric field intensity is 14kV, the total number concentration of sulfate aerosols decreases by 35.6% because of growth and agglomeration.

Evolution process of diesel engine exhaust carbonaceous particles during atmospheric dilution

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Abstract:

A comprehensive physical and chemical evolution process of the exhaust carbonaceous particles near the tailpipe was discussed as follows:

1. Based on the principle of nucleation, coagulation, condensation and evaporation and deposition, formation and variation of ultrafine particle during the exhaust dilution were simulation. Firstly, 1-2 nm critical clusters were formed by the homogeneous nucleation. The results showed that the nucleation rate and the critical nucleation diameter correlated to the temperature and humidity. Secondly, the critical cluster number concentration decreased and the critical cluster diameter moved to larger diameters for the process of coagulation. The accumulation mode in the exhaust suppressed the nucleation and condensation rates of the semi-volatile components. The nucleation and condensation processes of the semi-volatile components were promoted with low concentration accumulation, as a result, a lot of nucleation mode particles were produced.
2. Effects of the engine load, the dilution ratio, the TD temperature and the fuel type on the gas-particle partitioning of the carbonaceous particles at the near tailpipe region have been investigated. It is observed that, the engine load that can affect the total organic carbon emissions and the OC/EC ratio is considered as the dominated factor for the gas-particle partitioning of the semivolatile organic compounds. The phase partitioning of the organic aerosol is dominated by the adsorption mechanism at the near tailpipe dilution condition. The volatility distribution of the organic compounds is the major factor to determine the temperature sensitivity of the carbonaceous particles and the carbonaceous particles with a high volatility feature are found more sensitive to the temperature.
3. Based on an atmosphere-pressure flow reactor, the surface chemical aging process of the carbonaceous particles in the presence of NO₂ has been investigated to reveal the heterogeneous nitration mechanisms occurring on the carbonaceous particles in the dark and under the sunlight. the photochemistry of the carbonaceous particles in the presence of NO₂ is of great importance during the surface aging process of the carbonaceous particles, because it is not only a major photochemical source of HONO, but also a dominated aspect to determine the fates of PAHs and nitro-PAHs on the carbonaceous particles, further affecting the atmospheric chemistry balance as well as the toxicity feature of the carbonaceous particles.

New particle formation and growth at Baengnyeong Island, South Korea from 2013 to 2016

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Abstract:

New particle formation can be the dominant contributor to particle number and size distribution in the atmosphere, yet the phenomena for the particle formation are still poorly understood. In this study, we measured particle number size distributions (> 10 nm), gaseous species, PM_{2.5}, and meteorological parameters at Baengnyeong Island in South Korea from 2013 to 2016. Using the four-year data set, we performed a statistical analysis for the new particle formation and growth events together with meteorological conditions. New particle formation events at Baengnyeong Island commonly occurred when it was sunny and relative humidity was relatively low. These results will be discussed.

Light absorption properties of black and brown carbon aerosols in winter and summer Xi'an

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Abstract:

Black carbon (BC) and brown carbon (BrC) can affect earth's radiative balance by absorbing light. Two months of light absorption measurement and intensive observation campaigns during pollution periods in winter and summer were conducted in Xi'an, China. Light absorption properties of BC and BrC were investigated. Average absorption coefficients of BC (babs-BC) at 880nm and BrC (babs-BrC) at 370nm are 57.6 Mm⁻¹ and 34.2±18.9 Mm⁻¹ in winter, 11.1 Mm⁻¹ and 4.4±2.9 Mm⁻¹ in summer. Highest values of babs-BC and babs-BrC appeared at midnight in winter and early morning in summer. Lowest values of them are all achieved during afternoon. During winter pollution period caused by Particulate Matter (PM), babs-BC and babs-BrC are 120% and 80% higher while absorption Ångström exponents (AAE) between 370 and 880nm is 7% lower than that in winter non-pollution period. Mass absorption cross-section (MAC) of BC and BrC was enhanced at midnight by biomass burning emission and aqueous reaction, respectively. In summer pollution period caused by ozone (O₃), MAC of BC and BrC were weakened through photo-chemical access during day time. Source apportionment in winter pollution period showed that biomass burning is the largest contributor to both BC (30.63%) and BrC (29.09%) absorption. Traffic emission contributed 29.64% of babs-BC, 19.77% of babs-BrC, while coal burning contributed 27.68% of babs-BC, 21.47% babs-BrC, respectively.

Key words: Black carbon; Brown carbon; Pollution events; Source apportionment.

In situ observation of aerosol optical properties at the summit and middle of Mt. Fuji during summer campaign in 2018

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Abstract:

Atmospheric aerosol particles affect surface radiation budget of the Earth by scattering and absorbing solar radiation, depending on their optical properties. Therefore, it is important to accurately estimate single scattering albedo (SSA), which is the ratio of the scattering coefficient (σ_{scat}) to the extinction coefficient (σ_{ext}), and its spatial and temporal distributions. However, there is large uncertainties in the estimate of the σ_{scat} due to the detection limit of the measurement. In this study, we performed the development of new SSA retrieval method (SSA_ret) to estimate size-resolved aerosol concentrations for several chemical components. Using this method, we measured the aerosol optical properties at the summit (138.73E, 35.36N, 3776 m a.s.l.) and middle (138.80E, 35.33N, 1290 m a.s.l.) of Mt. Fuji.

Using the SSA_ret, we retrieved the aerosol size distributions for water-soluble particles and soot particles in fine mode and dust particles and sea salt particles in coarse mode by using the measured size-resolved aerosol number concentrations and their optical properties. Refractive indices of these chemical component are described in Hess et al. (1999). This algorithm was optimized with the Gauss-Newton method.

We estimated the SSA from the aerosol size distributions and scattering and absorption coefficients both at the summit and middle of Mt. Fuji in July 2018. The aerosol number concentrations, scattering coefficients, and absorption coefficients were measured by an optical particle counter (OPC, KC-01E, Rion), an integrated nephelometer (NEP, M903, Radiance Research) and a particle soot absorption photometer (PSAP, Radiance Research), respectively. The measurements of the OPC and NEP were

performed in a dry condition, i.e., lower than 30 % of relative humidity with a diffusion dryer. The PSAP measured light-absorbing particles (BC) with a heated inlet at 300 °C. In the result of observations at the summit and middle of Mt. Fuji, the scattering coefficients were 12.5 ± 5.9 /Mm and 36.4 ± 15.4 /Mm and the BC concentrations were 0.12 ± 0.09 $\mu\text{g}/\text{m}^3$ and 0.24 ± 0.12 $\mu\text{g}/\text{m}^3$, respectively. By retrieval with the SSA_ret algorithm, the fraction of the water-soluble particles of the extinction coefficient at 500 nm was 0.78 ± 0.12 and 0.84 ± 0.09 at the summit and middle, respectively. The mean SSA was 0.89 ± 0.04 and 0.92 ± 0.03 at the summit and middle, respectively. It is suggested the soot particles are transported to upper layer easier than other components and affect the vertical profile of the SSA.

Concentrations and light absorption properties of black carbon in Beijing during 2015-2017

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Abstract:

Based on the continuous measurements of BC and PM_{2.5} concentrations from 2015 to 2017, the spatial and temporal concentration levels, light absorption properties, regional transportation and influence mechanism of BC in Beijing were analyzed. The spatial distribution of BC concentration presents basically a trend of increase from north to south, and in the time distributions, BC concentration in Beijing showed a declining trend as a whole in the past years. Based on cluster analysis of trajectories, the concentrations of BC and PM_{2.5} along the air masses from northwest and southwest were high than other pathways. The meteorological fields of the trajectory distribution in 2016 and 2017 were adjusted on that in 2015, to quantify the influence on pollutants by meteorological conditions and source emissions. Results indicated that the impact on BC concentration and BC/PM_{2.5} of source emissions was far greater than that of meteorological conditions, the change rate of BC concentration caused by source emission was from -39.5% (2016) to -41.2% (2017). Instead, the change rate of PM_{2.5} concentration caused by meteorological conditions was much more than that caused by source emissions. The annual increases of AAE and AAEBrC were caused by the common effects of two factors.

Measurement of the Electrostatic Charging State of Individual Aerosol Particles by Kelvin Probe Force Microscopy

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Abstract:

Atmospheric particulate matters emitted from various sources have adverse effects on human health by deposition on the airways. Several studies have reported that the particle deposition in human airways is strongly enhanced by its electrostatic charging state. These facts clearly provide that aerosol particles with electrostatic charge deposit greater on human airways than it is expected from the particle size. Therefore, electrostatic charging state of aerosol particles is one of the key parameters of the human health impacts caused by aerosol. Nevertheless, few studies have focused on electrostatic charging state of individual atmospheric aerosol particles. In this study, we attempt to apply the method of Kelvin Probe Force Microscopy (KPFM) to measure electrostatic charging state of individual atmospheric particles.

KPFM is a method that enables imaging of nanometer-scale surface topography, and also surface potential of a sample. KPFM scans a sample with oscillating probe to detect interatomic force among the probe and the sample. Also, contact potential differences between the probe and sample are detected. These detections enable displaying of surface topography and potential of the sample.

We used glass substrate for aerosol collection and measurement medium. Prior to KPFM measurement of aerosol particles, we investigated whether the surface potential of the object on the glass substrate could be correctly measured by KPFM. For that purpose, we prepared a glass substrate with partially vapor deposited of Au. Using this substrate, we experimented whether the surface potential by the KPFM measurement coincide with an arbitrary voltage biased to the gold part on the glass substrate. As a result, when the bias voltage was changed by 0.5 V from 0 V to 2 V, the surface potential measured by the KPFM accurately represented the bias voltage. At least within this voltage range, the surface potential of an object on a glass substrate could be correctly measured by KPFM. Besides, the consistency of the bias voltage and the surface potential measured by KPFM was clearly obtained in the range of 0 to 0.4 V at the interval of 0.1 V.

KPFM measurement was carried out for indoor environment atmospheric aerosol particles collected with impaction onto a glass substrate. Aerosol particles with particle diameter of 0.3 - 0.5 μm were

collected. As a result of the KPFM measurement, all aerosol particles had a surface potential of 1 to 2 V more negative than that of the substrate.

Automatic Pressure feedback of tight-fitting PAPR

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Abstract:

Powered air-purifying respirators(PAPR) is a personal protective equipment which can deliver air under positive pressure to hood.Compared to traditional respirators,PAPR can improve the discomfort during long-term work.However, in order to maintain positive pressure , a big blower should be installed on PAPR to deliver sufficient air to hood, and then it will increase the weight on wearer.the purpose of our study is to use tight-fitting mask and small blower with pressure feedback system.Therefore, the flow rate on blower is changeable with the pressure of mask.Because of the tight-fitting mask, it can deliver the sufficient air with small blower, then the weight of the respirator system can be decrease.

We set two different breathing situation, normal breath and heavy breath respectively.Use 0.5 L of Tidal volume and 15 breaths per minute as normal breath and 1 L of tidal volume and 50 breaths per minute as heavy breath.We use a breathing simulator (MachineShop, combination of tidal volume and breathing frequency)and pressure meter(OMEGA ENGINEERING, INC DIFFERENTIAL PRESSURE TRANSMITTER) to measure the pressure drop in mask when breathing.the flow rate of the blower is measured with the flow rate meter(TSI 4100 Mass Flowmeters) .We assess the commercial PAPR with loose-fitting hood and tight-fitting mask,and find the minimum flow rate needed in two breathing situation.

To our experimental result,the Commercial PAPR with loose-fitting hood only deliver the fixed flow rate to hood no matter how the breathing change.The flow rate of the Commercial PAPR is about 226-270 L/min,and the pressure in the hood is 3.18 mm-H₂O.Although the positive pressure is useful for protecting, the high flow rate to the wearer who just walk or do some easy works is uncomfortable when breathing.In our respirator system with tight-fitting mask,the flow rate is needed about 21 L/min in normal breathing situation, and 170 L/min in heavy breath, and both pressure in the mask is only 0.51 mm-H₂O.Therefore,in our feedback system,the flow rate of the blower can not only adjust automatically along with the different breathing situation, but also provide wearer with a comfortable breathing condition.Moreover, with the feedback system,we may conserve the power of the blower when we use in normal situation instead of delivering the fixed flow rate like commercial PAPR.

Vertical Profiles of Atmospheric Aerosol in the Urban Canopy of a Megacity during Winter Haze Events

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Abstract:

North China Plain (NCP) with dense population suffers from heavy regional haze frequently. Over the past decades, extensive studies have been conducted in NCP region. While, most of conclusions and findings have been obtained based on the ground-level field measurements, which can not provide sufficient information to understand the vertical distributions of air pollutants, and the aerosol physicochemical processes within atmospheric boundary layer. Therefore, the measurements of vertical aerosol distributions are essential to comprehensively understand the formation mechanisms of regional air pollution. In this study, ground measurements (15m above the ground) were carried out on the campus of Peking University (PKU; 39°59'21" N, 116°18'25" E) in Beijing, China. The vertical measurements were conducted at the Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (39°58'28" N, 116°22'16" E). The IAP site is within 4 km of the PKU site. At the PKU site, the dry-state mass concentration of PM_{2.5} was measured using a TEOM 1400A analyzer. Dry-state particle number and size distribution (PNSD) were measured from 0.01 to 0.7 μm with a scanning mobility particle sizer (SMPS; TSI Inc. 3010). The data were collected from 1 to 22 December 2016. Additionally, relative humidity (RH), temperature (T), and wind direction and speed data were available during the measurement period. Vertical profile measurements were conducted from 6 to 20 December 2016 at the tower-based platform (maximum height 325 m) inside the IAP campus. The aerosol instrumentation package was installed aboard a movable cabin on the tower. The instrumentation package includes miniaturized portable scanning mobility particle sizer (Hy-SMPS) developed by Hanyang University determining the PNSD in the range of 8–245 nm, miniaturized optical particle counter (POPS; custom-built by NOAA Earth System Research Laboratory) measuring the PNSD in the range of 0.15–3.5 μm, a micro-aethalometer (AE-51; AethLabs) and SO₂ monitor. The ascending and descending track of cabin was recorded by a global positioning system (GPS). Also, T, RH and ambient air pressure were recorded in the meantime, respectively. In total, 12 vertical profiles were obtained during the field measurements. The vertical profiles of PNSDs and black carbon concentration showed difference

patterns in the atmosphere of the urban Canopy. During the heavy haze episodes, the particle number concentration of accumulation mode near ground is much higher than above 200 meter a.g.l, indicating an extremely low nocturnal boundary layer. In this study, the vertical profile of soot mass concentration and other key parameters will be presented to understand the fine structure of air pollutants in a urban canopy.

Elucidation of the relationship between the electrostatic charging state of ambient aerosols and meteorological condition by a parallel electrode plate device

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Abstract:

In recent years, the influence on health by fine aerosol particles such as PM_{2.5} has been concerned. Especially regarding the particle deposition in a human airway, some previous studies show that the deposition rate of charged particles to airway surface is several times than that of uncharged particles. In other words, when aerosol particles are inhaled, they are deposited on the airway more than expected from their particle size due to charging. However, little knowledge on the electrostatic charging state of atmospheric aerosols has been obtained so far. Therefore, in this study, the electrostatic charging state of atmospheric aerosols has been measured since April 2017 using a parallel electrode plate device utilizing the principle of electric mobility. We call this device K-MACS (Keio-Measurement System of Aerosol Charging State). The flow path of K-MACS is divided into three, and when +1.5 kV is applied, uncharged particles come out from the middle exit. Therefore we compare the number concentration of particles coming out from the middle exit with that of the inlet and calculate the proportion of uncharged particles.

The results varied depending on the measurement day, and the proportion of uncharged particles was about 12-25%. By investigating the relationship between the electrostatic charging state and the weather condition at the time of measurement, it was found that there was a strong positive correlation between the proportion of uncharged particles and the volumetric humidity. In order to investigate the uncharged particles proportion to the volumetric humidity, a continuous measurement of the uncharged particles proportion was conducted at the time of rainy weather condition in which the volumetric humidity easily changed. As a result, when volumetric humidity increased, volumetric humidity changed 25 minutes earlier than uncharged particles proportion. Also, when the uncharged

particles proportion increased, the uncharged particles proportion changed 20 minutes earlier than the volumetric humidity. In order to investigate the relationship between the proportion of uncharged particles and the volumetric humidity in more detail, we measured the electrostatic charging state while the volumetric humidity was manually changed. When a continuous measurement of the uncharged particles proportion was conducted at the time of sunny weather condition, there was a strong positive correlation between the proportion of uncharged particles and the oxidant concentration.

Change in PM_{2.5} exposure reduction capacity of an air purifier by wind-driven infiltration

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Abstract:

Abstract

Nowadays, there is a request for setting up guidelines to reduce the exposure to particulate matter (PM). PM is nominated as a source for various cardiopulmonary diseases, and it has been found that PM has an epidemiologically relationship with short-term and long-term or cumulative health effects. Control of indoor PM is especially important because most people spend their time in house. Air purifier is a device developed for reduction of indoor PM, however, there is an issue that in reality the performance of an air purifier is lower than the specification. In this study, the change in performance of an air purifier was investigated at living room of a common apartment house in South Korea. The volume of living room was 96.7m³. The area coverage specification of test air purifiers was 90m² or 60m², estimated in compliance with Korea air cleaning association standard. An optical particle counter (OPC, portable aerosol spectrometer, model 1.109, Grimm, Germany) was used to record particle size distribution within the range 0.25–32 μ m. An indoor air quality (IAQ) monitor (NDIR CO₂ Detector, model IQ-610xtra, GrayWolf Sensing Solutions, USA) was used to observe the CO₂ concentration in the range from 0 to 10,000 ppm. At the test house, the infiltration flow rate had a relationship with the outdoor wind speed, and the performance of an air purifier varied according to the wind speed. The indoor/outdoor ratio (I/O) of PM_{2.5} was within the range about from 3 to about 50%.

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The Study of the Variation of Carbonaceous Aerosols with Different Combination of Cooking Fuels in a Rural Village of Himachal Pradesh, India

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Abstract:

The climatic conditions of India are being governed by its hilly areas to a large extent. Various natural and anthropogenic factors are contributing to the air pollution at the local level such as forest fires, increased tourism, vehicular emissions, expanding human settlements, biomass burning (wood, dung cake, coal, kerosene oil, etc.). The residents in rural areas of hilly regions are mainly dependent on biomass for cooking and heating purposes, resulting in the increase of carbonaceous aerosols in the indoor environment. This study has been carried out in selected houses of Baggi, a small village in the Himachal Pradesh state of India, to evaluate the emissions of carbonaceous aerosol viz. Organic Carbon (OC) and Elemental Carbon (EC). Four houses with different structural specifications of the kitchen were selected and studied for the use of different combination of fuels being used for cooking. The indoor concentrations of OC and EC of these households were evaluated during the morning, afternoon and evening times which were the usual cooking times. It was found that when residents are using only biomass (wood) as a fuel for cooking, OC and EC concentrations were alarmingly high with average values of $240\mu\text{g}/\text{m}^3$ and $118\mu\text{g}/\text{m}^3$ respectively. With a combination of Liquefied Petroleum Gas (LPG) cylinders and biomass, the average values of OC and EC came down to some extent, $112\mu\text{g}/\text{m}^3$ and $68\mu\text{g}/\text{m}^3$ respectively. Although when the whole meal was cooked on LPG, a stark reduction of 84% in OC and 73% in EC concentrations was noticed when compared with biomass only cooking, suggesting that shifting to LPG will be highly beneficial health-wise as well as economically. The OC/EC ratio varied in the range of 0.8 to 2.9 which depicts that the indoor air pollution is being caused by the immediate pollution source, i.e., combustion of wood. The houses with good ventilation were found to have least concentrations OC ($48\mu\text{g}/\text{m}^3$) and EC ($38.6\mu\text{g}/\text{m}^3$) whereas the house with poor ventilation and smoker in the house accounted for highest concentrations, OC= $251.9\mu\text{g}/\text{m}^3$, and EC= $108.4\mu\text{g}/\text{m}^3$. Different combination of fuels and proper ventilation in the kitchen can bring down the concentrations of carbonaceous aerosols to a significant extent.

Indoor/outdoor characterization and sources of PM_{2.5}-bound PAHs, NPAHs and OPAHs in Jinan, China

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Abstract:

People spend 80% of their time indoors, therefore, the indoor air quality is particularly important to human health. Polycyclic aromatic hydrocarbons (PAHs) are teratogenic, carcinogenic, and mutagenic. Thus, they are harmful to the human. The concentration of their derivatives (NPAHs and OPAHs) are one or two orders of magnitude lower than PAHs, but they are more carcinogenic and teratogenic than PAHs. In order to study the pollution characteristics of indoor/outdoor PM_{2.5}-bound PAHs, NPAHs and OPAHs in urban and suburban hotels in Jinan, indoor/outdoor PM_{2.5} samples were collected at both urban and suburban hotels in Jinan in January 2016. 18 PAHs, 16 NPAHs, and 5 OPAHs were analyzed by using gas chromatography-mass spectrometry. The indoor/outdoor concentration, indoor and outdoor relationships, source, and carcinogenic risk of PM_{2.5}-bound PAHs, NPAHs, and OPAHs were studied in urban and suburban of Jinan.

Based on the experimental data, the indoor and outdoor concentrations of PM_{2.5}-bound PAHs, NPAHs, and OPAHs in urban and suburban hotels were obtained. The concentrations of PM_{2.5}-bound PAHs, NPAHs, and OPAHs in urban areas were higher than suburban; the concentrations of outdoor PM_{2.5}-bound PAHs, NPAHs, and OPAHs were higher than indoor, except urban hotel2. There was no significant difference in the composition of PAHs and their derivatives in this study area. 4-ring PAHs (such as Flt, PYR, BaA, Chr) were predominated at PAHs; 9N-ANT and 2+3N-FLA were the dominant NPAHs; and 9-FO was the most abundant OPAHs at all sites.

Through indoor/outdoor concentration comparison (I/O) of PM_{2.5}-bound PAHs and their derivatives, we found that the I/O of PAHs, NPAHs, and OPAHs in urban hotels1 and suburban hotel were less than 1, indicating that they mainly come from outdoor sources; in urban hotel2, the I/O of 2-3 ring PAHs, 2-3 ring NPAHs (except 3N-BYL and 9N-ANT) and OPAHs were greater than 1, which are mainly from indoor sources .

Principal component analysis (PCA) and characteristic ratio method were used to analyze the source of PM_{2.5}-bound PAHs, NPAHs and OPAHs in this study area. The results shown that the main sources of PM_{2.5}-bound PAHs in this study area were solid fuel combustion and motor vehicle exhaust ; the main sources of NPAHs and OPAHs were solid fuel combustion, motor vehicle exhaust and secondary generation. We also found that the secondary generation pathways of NPAHs in this study area was caused by OH·.

The assessment of the cancer risk of human health exposure to PM_{2.5}-bound PAHs and NPAHs in hotels indoor and outdoor of urban and suburban in Jinan was performed by calculating the incremental lifetime cancer risk (ILCR). It was found that when human exposed to urban outdoor have highest cancer

risk. The ILCR values in urban air environment were higher than suburban; and in outdoor environment were higher than indoor. The ILCR value of PM_{2.5}-bound PAHs in the indoor atmosphere decreased as the distance from the traffic source increases. However, the ILCR values of PM_{2.5}-bound NPAHs in urban hotels² were higher than other hotels, which may be due to its obvious kitchen cooking activities.

Evaluation of mask performance to prevent idiopathic environmental intolerance

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Abstract:

In recent years, a disease called idiopathic environmental intolerance (IEI, also called multiple chemical sensitivities) has become serious. IEI refers to a syndrome characterized by a wide range of somatic symptom disorders that purportedly arise in response to environmental triggers, but for which there is no concrete evidence of an underlying physiological. Sometimes IEI develops in conjunction with the sick house syndrome that develops due to a certain indoor environment. Since actual condition has not been clarified at all, IEI was classified as "Toxic effect of unspecified substance" in statistical classification of disease, injury and death cause made by World Health Organization (WHO) in 2009.

We try to develop a device that reduces the cause of symptom onset, and compare the onset state of IEI and wearing state of the device based on patient's vital data. The purpose of this research is to elucidate the true factor causing IEI.

We are considering developing a mask type device that can be used in daily life for IEI patients. The collection efficiency of atmospheric particles (concentration of particles collected by the mask / concentration of all particles) was measured using four types of masks for reducing hypersensitivity (containing activated charcoal filter) and one type of mask for general use. For the experiments, optical particle counter (KC-01, RION, Japan) was used to measure particle number concentration. Indoor air was introduced into a 47 mm diameter filter holder containing the cut mask at a flow rate of 0.5 L/min. As a result, there was a hypersensitive mask with a collection efficiency of less than 90% with particles of 0.3 to 0.5 μm even under a very low air flow rate of 0.5 L/min compared to typical human respiratory flow rate of 7 to 20 L/min. The general purpose mask resulted in the best particle collection efficiency. It seems that the hypersensitive masks are not designed to collect entire particulate matter in ambient air.

The sick house syndrome (SHS), which often develops to IEI if it becomes more serious, is mainly caused by volatile organic compounds (VOC) in the indoor environment. Therefore, collection efficiency of VOC by mask was also measured. For the experiments, ppb-RAE (PGM-7240, RAE systems, USA) was used to measure total volatile organic compounds (TVOC) concentration. Indoor air was introduced into a 47 mm diameter filter holder containing the cut mask at a flow rate of 20 L/min. We are considering the implementation of mask type devices specialized for collecting not only particulate matter but also VOC in the future.

Source Contribution to PM_{2.5} Concentration in Multifamily Housing Units

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Abstract:

Recently, the concerns on adverse health effects due to high outdoor particle concentration has been raised in Korea. Although, Korean government advises people to stay in buildings when outdoor particle concentration is high, people can be exposed to high concentration particle due to outdoor-originated particles entering through building crack. Outdoor particle penetration depends on various building factors and environmental conditions. Therefore, analysis on contribution of indoor and outdoor sources to particle concentration would be useful for understanding how much particles are penetrated from outdoors and generated from indoors. The objective of this study is to analyze source contribution to PM_{2.5} concentration in multifamily housing units in Korea. CONTAMW simulation was conducted to predict annual indoor PM_{2.5} concentration for two multifamily housing units located in urban area with different building airtightness. Simulation cases were set with consideration of penetration of outdoor particle indoor PM_{2.5} generation. For the simulation, on-site experiments were carried out to determine building leakage, particle penetration coefficient and deposition loss rate. Contribution of indoor and outdoor sources to annual indoor PM_{2.5} was analyzed based on estimation of annual indoor PM_{2.5} concentration. The results showed that the annual indoor PM_{2.5} concentration with assumption of no indoor generation in the leaky housing unit was 3.9 times higher on average than the airtight housing unit. Especially, indoor PM_{2.5} concentration with assumption of no indoor generation in leaky housing units in March exceeded Korean environmental standard for daily outdoor PM_{2.5} concentration (35 µg/m³). The annual indoor PM_{2.5} concentration with indoor generation in leaky housing unit was 1.2 times higher on average than the airtight housing unit. Indoor PM_{2.5} concentration in the airtight housing unit with accumulation of indoor sources caused by low air exchange rate was similar with the leaky housing unit in summer. Contribution of indoor sources to indoor concentration in leaky housing unit and airtight housing unit was 82% and 96% in summer, and 63% and 90% in winter, respectively. Contribution of outdoor sources to indoor concentration in the leaky housing unit and airtight housing unit was 18% and 4% in summer, and 37% and 10% in winter, respectively. The study demonstrated that the leaky housing unit is more vulnerable to indoor particle exposures than airtight housing unit and suggested the source contribution to PM_{2.5} concentration in multifamily housing unit depending on building airtightness and weather conditions.

Particle decay analysis according to the position of an air cleaner in a four-bed ward

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Abstract:

Airborne particles can contain viruses which cause patients in the hospital ward to be infected. As a way to remove those harmful virus-containing particles, an air cleaner can be used in the hospital ward. In this study, we experimentally analyzed the local air quality according to the position of the air cleaner in a four-bed ward. The decay rate of particle concentration at local positions was used as the index to evaluate the local air quality. The analysis was also conducted under the operation of a ventilation system and the use of ward curtains. It was found that the local air quality was greatly influenced by the position of the air cleaner in the four-bed ward. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning, Grant number: 2017R1A2B2006927. ysjnuri@hanyang.ac.kr.

Methodology to estimate performance of onepass-type air sterilization system using UVC LED in a chamber for inactivating aerosolized virus.

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Abstract:

This study is aimed to evaluate the performance of onepass-type air sterilization system with virus contaminated air in a sealed chamber by using UVC LED and propose a model to estimate real sterilization performance. A model for predicting the chamber sterilization performance was derived from calculation method of filter-based air cleaner performance. Using the data of sterilization performances obtained from the chamber experiment, the correlation work was applied on the above model. According to the experiment, the chamber sterilization performance was 1.81 times higher than expected by onepass-type system's specification. If the germicidal effect only occurs inside the onepass-type system, the chamber sterilization performance should be less than 1x the spec of the onepass-type system due to the flow in the chamber. Therefore, the above result means that viruses passing through the onepass-type system were being further sterilized as they circulate through the chamber from outside the onepass-type system. This considered to be because the virus was physically damaged even if the virus was not completely inactivated in the onepass-type system. The viruses damaged by the UVC were inactivated itself faster than when they were intact in the air. These results can be utilized as an important data for setting the target sterilization performance in UVC sterilization equipment design such as air sterilizer.

An Experimental Study of Particle Deposition on Micro-ribbed Surface in a Chamber

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Abstract:

Nowadays, because people spend more time indoors than outdoors, their health is being influenced by the indoor air quality. Particles smaller than $10\ \mu\text{m}$ (PM10) can be easily inhaled by human beings, leading to serious lung diseases. Therefore, it is necessary to develop a highly efficient particle removal system to improve indoor air quality. Aerosol removal systems are widely used in indoor environments but many of them are not efficient for small particles, especially in the submicron range ($0.1\text{--}1\ \mu\text{m}$). For example, HEPA filters can remove some of them but they are expensive to maintain because they need to be replaced on a regular basis. Aerodynamics type air cleaners, e.g. cyclones, are lower in cost and easier to maintain, but they still face the low removal efficiency for submicron particles. So it is expected to find a simple and low-cost way to enhance their efficiency. On one hand, it has been found that the particle collection performance on some air cleaners, such as electrostatic precipitators, can be significantly enhanced by an arrangement of repeated surface ribs. On the other hand, it is well known that roughness in micrometer scale increases the particle deposition rate and certain experiments have revealed that a ribbed surface in millimeter scale on the wall can also enhance the deposition. Inspired by this, it is expected that the removal efficiency, especially for submicron particles, can be further enhanced by adding ribs in micrometer scale on surfaces of the air cleaning system to enhance particle deposition.

In this study, the relationship between the particle deposition effect and the geometrical parameters of the rib was studied experimentally. Two different rib shapes, convex semi-circular and concave semi-circular, and for each shape, five different ratios of rib height to rib pitch were investigated. All samples were fabricated by 3D printing and the smallest ribs are in micrometer scale. In each experiment, only one sample was put on the bottom surface of a well-sealed chamber. Dust particles with diameters ranging from 0.3 to $5\ \mu\text{m}$ were injected to the chamber until a specific concentration was achieved. A fan in the middle of the chamber produced a turbulent flow, thoroughly mixing the air inside. The number concentration of different particle sizes inside the chamber was measured during the experiments. The particle deposition rate due to the ribbed surface was calculated by the concentration decay method. Relative deposition rate, which is defined as the deposition rate on micro-ribbed surfaces divided by the deposition rate on a non-patterned surface, was introduced to evaluate the

enhancement effects. The results show that both the shape and aspect ratio have obvious effects on particle deposition for different particle sizes. For submicron particles, the enhancement effects are positive, showing a strong correlation with the particle size. The mechanism of particle deposition on different micro-ribbed surfaces was also compared and discussed. The results of this study suggest a possible particle deposition enhancement approach using micro-ribbed surfaces which could be a reference for considering efficiency enhancement of aerosol removal systems.

Characteristics of Nanoparticle Formation and Hazardous Air Pollutants Emitted by 3D Printer Operations: from Emission to Inhalation

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Abstract:

This study examined the emissions of nanoparticles and hazardous air pollutants (HAPs) by 3D printer operations and evaluated nanoparticle deposition behavior using a prediction model. Nanoparticles and HAPs were sampled at the Inha University 3D printing center with five fused filament fabrication (FFF)-type 3D printers. The number size distribution of the nanoparticles exhibited a bimodal distribution with dominant peaks over a large size range between 70 and 100 nm and smaller size range between 10 and 20 nm. With increasing 3D printer operation, the number concentration of 10 nm particles increased, and the final number concentration was 3.6 times higher than that of the background concentration. Nanoparticle formation and agglomeration were characterized by transmission electron microscopy (TEM) analysis and were mostly composed of Si, S, and K. Model calculations revealed that a large number of nanoparticles between 10 and 30 nm in size are deposited in the lower human respiratory tracts (generation number: 16–22) of the human respiratory tract. A total of 15 HAPs species were detected, among which hexane, acrylonitrile, and benzene concentrations were the highest.

This study was funded by the Korea Ministry of Environment (MOE) as “the Environmental Health Action Program (2016001360005)”

Personal exposure to PM_{2.5}-bound organic species from domestic solid fuel combustion in rural Guanzhong Basin, China

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Abstract:

Domestic solid fuel combustion for household heating produces a mass of fine particulate matter (PM_{2.5}). Its emissions of particulate-bound organics, including polycyclic aromatic hydrocarbons (PAHs), oxygenated-PAHs (OPAHs), phthalate esters (PAEs) and hopanes, were demonstrated and quantified in rural Guanzhong Plain, northwestern China. Ten female participants were selected for personal exposure assessment. The average concentration of total quantified PAHs (\sum PAHs) in personal exposure samples was 310.3 ± 443.2 ng/m³, 1.5 times of those of indoor (210.9 ± 119.9 ng/m³) and outdoor (189.0 ± 114.8 ng/m³). Similar observations were seen for the OPAHs and PAEs while much higher concentrations were seen in the personal exposure samples than the indoors and outdoors. For hopanes, the average personal exposure level (13.0 ± 9.7 ng/m³) was slightly below the indoor (15.4 ± 9.7 ng/m³) and outdoor (13.3 ± 9.6 ng/m³), suggesting relatively uniform impacts from fossil fuel combustions from surrounding environments. On the basis of four different heating ways applied in the dwelling, the highest exposure levels to PAHs, OPAHs and PAEs were found for the indoor coal chunks stoves. Electric power was proved to be the cleanest energy for the household heating, 1.2-4.5 folds lower than those with other solid fuels used. The exposures to the PM_{2.5} on cell viabilities were also investigated. The largest reduction of 69.7% on cell viabilities was seen for the indoor coal chunks stoves, indicating that the emissions from coal combustion had greatest cytotoxic effects. In addition, statistical analysis shows that PAHs were more correlated with cell viabilities than OPAHs and PAEs. The results evidenced that the heating ways in rural area could greatly impact on the residents health, particularly for housewives, in northwestern China. Advanced heating ways and protection should be conducted to reduce the exposures from toxic chemicals from domestic solid fuels combustions.

High-resolution sampling and analysis of air particulate matter in the Pear River Delta region of Southern China: source apportionment and health risk assessment

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Abstract:

Hazardous air pollutants, such as trace elements in particulate matters (PM), are known or highly suspected to cause detrimental effects on human health. To understand the sources and associated risks of PM to human health, hourly time-integrated major trace elements in size-segregated coarse (PM_{10-2.5}) and fine (PM_{2.5}) particulate matter were collected and examined in an industrial city of Foshan in the Pearl River Delta region, China. Receptor modeling of the dataset by positive matrix factorization (PMF) was used to identify six sources contributing to PM_{2.5} and PM₁₀ concentrations at the site. Dominant sources included industrial coal combustion, secondary inorganic aerosol, motor vehicles and construction dust along with two intermittent sources, biomass combustion and marine aerosol. The biomass combustion source was found to be a significant contributor to peak PM_{2.5} episodes along with motor vehicles and industrial coal combustion. Conditional probability function (CPF) was applied to estimate the local source effects from wind direction using the PMF-resolved source contribution coupled with the surface wind direction data. Health exposure risk for hazardous trace elements (Pb, As, Cr, Ni, Zn, V, Cu, Mn, Fe) and source-specific values were estimated. The total hazard quotient (total HQ = HI) of PM_{2.5} was 2.09, which is two times higher than the acceptable limit (HQ = 1). The total carcinogenic risk was 3.37×10^{-3} for PM_{2.5}, which was three orders higher than the acceptable limit (i.e. 1.0×10^{-6}). Among the selected trace elements, As and Pb posed the highest non-carcinogenic and carcinogenic risks for human health, respectively. In addition, our results showed that industrial coal combustion source was the dominant non-carcinogenic and carcinogenic risks contributor, highlighting the need for stringent control of this source. This study can provide new insight for policy makers to prioritize sources in air quality management and health risk reduction.

KEYWORDS: Particulate matter, source apportionment, health risk assessment, PRD.

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Indoor-outdoor pollution characteristics of metal elements of PM_{2.5} in summer Qian'an City

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Abstract:

To study on the pollution characteristics of elements in PM_{2.5} in summer in Qian'an City, indoor-outdoor PM_{2.5} samples were collected in 2016. The method of enrichment factor was discussed to evaluate the pollution degree of metal elements in PM_{2.5}. The results showed that PM_{2.5} pollution in coal-fired area was more serious than that in non-coal-fired area, and indoor PM_{2.5} pollution was more serious than outdoor PM_{2.5}. The mass concentration of all indoor elements coal-fired and non-coal-fired areas were higher than those outdoor elements. The element of Cd was highly enriched in all environment, but the element of Cu, Ni and Pb was different enrichment degree in different environment.

Evaluation of a small whole-body exposure chamber (sWBEC) for mice

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Abstract:

Inhalation chambers designed for small exposure groups are useful for the screening and efficacy testing of new drugs due to their limited availability and potentially high cost. A SCIREQ InExpose™ whole-body exposure chamber for mice was modified to enable characterization of the test atmosphere within the chamber during exposure, to improve animal loading/unloading procedures and for mechanical integration with existing systems within our facility. Whole body exposure mode is the most appropriate way for inhalation exposure of mice and minimizes stress-related effects. Due to the availability of many different strains of mice, they are often the most useful species to study specific diseases (e.g. CVD, lung cancer). The sWBEC has 16 positions of which typically 15 are used for exposure and 1 for sample collection to enable characterization of the test atmosphere. The sWBEC has a volume of ~5L and therefore requires a low amount of test item to be delivered to the chamber while respecting a minimum number of air changes as recommended in test guidelines from the Organisation for Economic Co-operation and Development (OECD).

Tests were performed to determine the spatial and temporal homogeneity of the sWBEC using an aerosol generated by nebulizing a liquid solution of nicotine dissolved in propylene glycol and glycerin vehicle. The mass median aerodynamic diameter (MMAD) and geometric standard deviation (GSD) of the aerosol were 1-1.5 µm and 1.3-1.8 respectively.

The spatial homogeneity was quantified by determining via gravimetric methods the amount of mass deposited passively onto filter pads placed at various positions within the sWBEC. Passive deposition as opposed to the active drawing of aerosol out of the chamber was preferred for the determination of spatial homogeneity to avoid altering the flow patterns within the sWBEC. The spatial variation of the mass passively deposited on the filter pads resulted in coefficients of variation (CV) of 14%.

The temporal homogeneity was quantified by drawing aerosol from within the sWBEC to determine the concentration of nicotine at 5 time points distributed over a 6 hours period. Passive deposition was not

applied here as the concentration of nicotine in the sWBEC cannot be quantified based on the amount deposited passively on the filter pad. The temporal variation of nicotine concentration in the sWBEC over 6 hours resulted in a CV value of 7.6%. The time to reach 95% of the equilibrium nicotine concentration (t_{95}) was estimated to be ~70 mins using the equation described in Pauluhn 2007.

Our evaluation of the sWBEC demonstrated that the aerosol distribution within the sWBEC is comparable to that of exposure chambers evaluated by other investigators (O'Shaughnessy 2008, Cheng & Moss 1995). The t_{95} for nicotine is a parameter that has not been reported prior to this. The results from this work can therefore further the understanding and serve as a basis for comparing the aerosol dynamics between exposure chambers.

Development and Performance Evaluation of Dry Powder Aerosol Generator for Inhalation Toxicity Testing of Nanomaterials

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Abstract:

Recently, with the rapid development of nanotechnology, many nanomaterials are being produced. These nanomaterials have unique characteristics that are quite different from those in the lump form and are widely used in many industrial fields. However, these nanomaterials may enter the body through the respiratory tract and cause pulmonary fibrosis in the lungs or may precipitate in the alveoli causing inflammation, which may be transferred to other organs through the blood vessels in the lungs, leading to secondary toxicity. As a result, the current risk assessment of nanomaterials is becoming a global issue. In order to perform inhalation toxicity test, a nano-particle dispersion in the air is the most important step for the evaluation of the risk of nanomaterials. After the dispersion, nano-particles can then be inhaled by laboratory animals.

In this study, we developed a dry powder aerosol generator for inhalation toxicity testing of nanomaterials. The developed dry powder aerosol generator performance was evaluated and the factors that could affect the aerosol generation were verified with the inhalation toxicity testing method that recommended by OECD guideline. The short-term / sub-chronic inhalation toxicity testing of carbon nano-fiber (CNF) was performed using the dry powder aerosol generator to verify the performance of an aerosol generation for inhalation toxicity test of nanomaterials. The dry powder aerosol generator developed in this study is expected to contribute to the study of inhalation toxicity study of nanomaterials.

In vitro toxicity evaluation of heavy metals in urban air particulate matter on human lung epithelial cells

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Abstract:

Heavy metals are widely recognized as toxic components in urban air particulate matter (PM). However, the major toxic metals and their interactions are poorly understood. In this study, we attempted to explore the toxicity contribution and combined effects of PM contained metals in human lung epithelial cells (A549). The cell viability of A549 increased significantly (22.9%) after metal removal in PM, demonstrating an important contribution of metal components to PM toxicity. Among eleven elements examined (Zn, Cr, Mn, Fe, Ni, Cu, As, Se, Sr, Cd, and Pb), six heavy metals (Zn, Cr, Mn, Fe, Cu, and Pb) might account for PM toxicity in A549 cells. For combination treatments, Mn was found to be a “synergistic agent”, while Fe usually served as an “antagonistic agent”. The varied effects of other metals (Zn, Cu, Pb and Cr) on different metal mixtures might be explained by their interactions (e.g., similar or dissimilar membrane transporters and intracellular targets). Besides, the concentration addition model (CA), independent action model (IA), integrated addition model (IAM) and integrated addition and interaction model (IAI) were used to predict mixture toxicity, and the IAI model exhibited the least variation. Our results emphasize the potential contribution of heavy metals to PM toxicity and their interactions, and promote the application of toxicity prediction models to metal components in PM.

Characterization of An Exposure System for Assessing Effects of Inhalation Exposure to PM_{2.5} in Vitro

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Abstract:

To assess cellular exposure to inhaled PM_{2.5}, this study characterizes the size distribution and contact efficiency of airborne particulates introduced into an in vitro exposure system, comprising of an aerosol generation system (scanning mobility particle sizer (SMPS)) together with a cellular exposure chamber (CULTEX®). Particle number size distribution (PNSD) is measured before entering and after leaving the cellular exposure chamber. To characterize background interference, atomization of ultrapure water alone generates aerosols with a geometric mean size of 32.8 nm at number concentrations within 30% of standard particles. Ammonium sulfate and carbon black (CB) are first aerosolized individually as surrogate airborne particles of ambient PM_{2.5}. Prior to aerosolization, the aqueous CB suspension was observed by dynamic light scattering (DLS) measurements to exhibit moderately disperse distribution with a polydispersity ranging from 0.14–0.22 and an effective diameter of 257.5 nm. This indicates that CB particles are substantially agglomerated in aqueous suspension. Upon aerosolization, airborne CB shows a bi-modal distribution with a smaller geometric mean size closer to the reported primary particles (50–80 nm), indicating disintegration of atomized sub-micron colloids. At the outlet of the exposure chamber conditioned with a relative humidity above 60%, both airborne ammonium sulfate and CB increased in the geometric mean size by more than 5 nm, suggesting potential re-agglomeration of airborne particles within the exposure chamber. The results show that depending on types and sizes of airborne particles, the duration required to expose cell lines to a constant dose of airborne particles varies, indicating the importance of detailed characterization of the properties of airborne particles before linking with resultant cellular effects. Additional analyses will be provided in terms of how initial solution concentrations affect the amounts and size distribution of airborne particles interacting with cell lines in the exposure system.

Vehicle emissions of carbonaceous compounds and the toxicity to human lungs in the Shing Mun Tunnel, Hong Kong

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Abstract:

Exposure to vehicle emissions has been linked to cardiopulmonary diseases by epidemiological and toxicological studies. However, the cytotoxicity of vehicle emission as a single source was less well investigated. In this study, the emission characteristics of Hong Kong vehicles were obtained by a tunnel study in Shing Mun Tunnel, and the oxidative and inflammatory responses of vehicle emitted PM_{2.5} to human A549 lung alveolar epithelial cells were also investigated. The emission factor (EF) of PM_{2.5} and total polycyclic aromatic hydrocarbons (PAHs) was 27.2 ± 12.0 mg vehicle⁻¹ km⁻¹ and 2.24 ± 1.67 μ g vehicle⁻¹ km⁻¹. Diesel-fueled vehicles (DV) showed higher EFs than non-diesel-fueled vehicles (NDV) though with a lower traffic count. Vehicle emitted PM_{2.5} caused significant alterations in cytotoxicity, oxidative stress and inflammations to A549 cells. OC, EC and individual PAHs (ACY, FLO, PHE, BaA, CHR, BaF, PER, DaeP) showed high correlations with Lactic dehydrogenase (LDH) and interleukin-6 (IL-6). DV contributed 84.1% to LDH and 75.2% to IL-6 releasing when exposure to A549 cells, indicated the major contributions of DV to the cytotoxic effects. This study provide a broader understanding of the toxicity of single emission sources and their relationships to PM_{2.5} chemical species, the contributions of DV and NDV were also estimated.

Reactive Oxygen Species (ROS) activity of ambient fine particles (PM_{2.5}) measured in Seoul, Korea

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Abstract:

Substantial increase in level of particulate matter has raised concerns in South Korea recently. Fine particulate matter (PM_{2.5}) which has a diameter less than 2.5 μm is likely to penetrate deeply into lung and is known to be eliciting adverse health effects. The objective of this study was to assess PM-induced oxidative potential by relating PM-induced oxidative potential with chemical constituents and possible sources in Seoul, Korea. Ambient PM_{2.5} samples were collected at the rooftop of former Seoul National University Graduate School of Public Health building for 24-hr period from September 2013 to May 2015. A low-volume air sampler consisting of cyclone and filter pack system was loaded with Teflon filter, quartz microfiber filter, and zefluor filter. Teflon filter was used for PM_{2.5} mass concentration measurement, elemental analysis by Energy Dispersive X-ray Fluorescence and ROS analysis using in vitro macrophage assay. Zefluor filters were used for ionic chemical analysis using Ion Chromatography and quartz filters were used to measure organic carbon (OC) and elemental carbon (EC) which were quantified by Carbon Aerosol Analyzer. PM_{2.5} mass concentration during the cold season was relatively higher than mass concentration during the warm season and chemical constituents except for Secondary Organic Carbon (SOC) and SO₄²⁻ followed similar trends. The concentration of crustal elements was especially high during the cold season which can be an indication of long range transport of Asian dust. Water soluble organic carbon and transition metals (Cr and Zn) were also shown to be correlated to oxidative potential and metals such as As and V were shown to have a high contribution to ROS activity. Identified six factors that can be interpreted as soil, mobile, industry, secondary inorganic aerosol, secondary organic aerosol and oil combustion. Moreover, through Principal Component Regression (PCR), industry, soil, mobile and SIA were shown to be statistically significant sources in a relation to ROS activity. A number of epidemiological studies have been conducted on adverse health effects of PM-related diseases and mortality rate, yet particulate matter (PM)-induced reactive oxygen species (ROS) activity at the cellular level has not been actively studied in Korea. Oxidative potential was consistently detected at all levels of PM_{2.5} mass concentration, thus it is more important to implement reduction policy based on chemical constituents and sources instead of reducing PM_{2.5} mass concentration itself.

Toward differential toxicity of fine particles from equal toxicity

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Abstract:

Fine particulate matter (PM_{2.5}) in the ambient atmosphere are strongly associated with adverse health effects. However, it is unlikely that all PM_{2.5} are equally toxic in view of their different sizes and chemical components. Identification of differential toxicity of PM is a difficult task because the PM is a complex mixture of various chemical components that vary in size, shape, chemical composition, reactivity, and solubility. Determination of source-specific toxicity can be an alternative way to disentangle effects of PM on human health rather than chemical component-specific toxicity measurement. The goal of this study is to assess variability in toxicity of particles produced from various sources, diesel and gasoline engine, biomass burning, coal burning, and dust, including secondary organic aerosols. Chemical characteristics such as ion, metal, organic carbon (OC)/elemental carbon (EC) was determined by ion chromatography (IC), inductively coupled plasma mass spectrometry (ICP-MS), and thermal-optical transmittance (TOT) method, respectively. OC speciation was conducted by gas

chromatography-mass spectrometry (GC-MS). Toxicity test was conducted using chemical and biological assays. For chemical assay, oxidative potential (OP) was measured by OP_DTT and OP_ESR. For biological assay, various end points, cytotoxicity, mutagenicity, oxidative stress, and inflammation, were determined by neutral red uptake (NRU) assay and water soluble tetrazolium salt (WST-1), Ames test and comet assay, DCF-DA (2',7'-dichlorofluorescein diacetate) assay, IL-6 and IL-8, respectively. Multiple biological and chemical endpoints were integrated for various aerosols to derive toxicity scores for particles originating from different sources. The highest toxicity score was obtained for diesel engine exhaust particles, followed by gasoline engine exhaust particles, biomass burning particles, coal combustion particles, and road dust, suggesting that traffic plays the most critical role in enhancing the toxic effects of fine particles. The toxicity ranking of fine particles produced from various sources can be used to better understand the adverse health effects caused by different fine particle types in the ambient atmosphere, and to provide practical management of fine particles beyond what can be achieved only using PM mass which is the current regulation standard.

Association of commuter exposure to fine particles, black carbon, and elements with PM_{2.5} bioreactivity in Hong Kong

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Abstract:

Background

Human exposure to traffic-related pollutants in transit is frequently higher than the corresponding ambient concentrations. Personal exposure measurement in transport microenvironments was conducted to investigate the health risks of traffic-related particles.

Method

Commuter exposure measurements were conducted during the summer and winter season of 2016-2017, respectively. Integrated personal measurement along with real-time PM_{2.5} and BC monitoring were conducted six days per week (i.e., from Monday to Saturday) throughout the study period. On each day, trained technicians collected exposure samples during the peak (e.g., 08:00-11:00, 17:30-20:30) and off-peak (13:00-16:00) times of the day. The selected transport modes (MTR and bus) that represent > 70% of the modal distribution in Hong Kong were evaluated simultaneously at different sampling routes. Samples were analyzed for mass by gravimetric analysis. Elements (from Na to Pb) will be analyzed using X-Ray Fluorescence. Further, Teflon filters will also be analyzed to characterize the toxicological effects of fine particles components.

Results

Personal exposure to PM_{2.5} and BC in MTR cabin ranged from 39.0 to 79.4 µg/m³ and 4.3 to 8.6 µg/m³, respectively. MTR was the mode of transport with significantly higher levels of pollutants ($p < 0.01$). Corresponding exposure levels in the bus were 10.6-17.5 µg/m³ and 3.4-4.6 µg/m³ for PM_{2.5} and BC, respectively. Personal exposure to PM_{2.5} and BC in different transit microenvironments (e.g., MTR, bus) exhibited the same season trends with higher levels in winter and lower levels in summer ($p < 0.05$). Diurnal fluctuations of in-cabin personal PM_{2.5} and BC exposures were marked with two peaks, one in the morning rush hour and the other in the evening traffic time. Further, between-route variations were shown in this analysis, with significantly higher exposures in sampling route between Hung Hom and University station in Hong Kong for both PM_{2.5} and BC.

Conclusion:

This study provides useful information to better characterize commuter exposure in various transport mode across different sampling routes. There was significant between-route variation, most notably

between the East railway line and the Island line in Hong Kong. Further, the fixed-route exposure showed a significant difference in levels across transport modes.

Keywords: personal monitoring, commuters' exposure, black carbon, elements constituents, toxicological effects

Acknowledgements

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Concentration characteristics and health risk assessment of heavy metals in PM_{2.5} during the BRICS Summit in Xiamen

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Abstract:

Background, Aims and Scope. PM_{2.5} (particulate matter with diameter less than 2.5 μm) could exist and transport for long distant in atmosphere. It not only affects the environmental quality but also shows a risk to human health. PM_{2.5} contained with heavy metals enter human alveolar directly, damage organ, even cause cancer. Thus, it's necessary to know the health risk and take effective control measures for concentrations of heavy metals in PM_{2.5}.

Methods. Two sampling sites were set in Xiamen. One was set on the roof of Ruijing Primary School (4.48°N, 118.15°E) in Xiamen island, which was taken as the urban site. Another one was set on the roof of teaching building in Huaqiao University (24.61°N, 118.08°E) in Jimei peninsula, which was taken as the suburban site. The PM_{2.5} samples were collected using TH-150A intelligent volume samplers and 90-mm diameter polytetrafluoroethylene membranes before (Aug. 8th to Aug. 26th, 2017), during (Sep 1st to Sep 6th, 2017) and after (Sep 7th to Sep 10th, 2017) the BRICS Summit. Inductively coupled plasma source mass spectrometry was used for testing the concentrations of V, Cr, Co, Ni, Cu, Zn, As, Cd, Pb.

Results and Discussion. During the BRICS Summit, PM_{2.5} concentrations were 24.96 and 29.66 μg·m⁻³ in urban and suburban, respectively, which were lower than those of the first limit of China (μg·m⁻³). The concentrations of heavy metals in PM_{2.5} were 0.158 and 0.165 μg·m⁻³, respectively. The results showed that the concentrations of PM_{2.5} and heavy metals had decreased during the BRICS Summit, indicating control vehicle flow, factory shutdown and other measures during the BRICS Summit were effectively. The results of health risk assessment of heavy metals in PM_{2.5} showed that the non-carcinogenic risk of all heavy metals can be ignored, however, carcinogenic risks for Cr, Co, Ni, As and Cd were above the threshold value.

Conclusion. The results indicated that control vehicle flow, factory shutdown and other measures during the BRICS Summit can reduce PM_{2.5} pollution. However, Cr, Co, Ni, As and Cd still had carcinogenic risk to human people.

Estimation of particulate matter inhalation dose by breathing in common transport microenvironments in Seoul, Korea

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Abstract:

Recently, people's interest in particulate matter (PM) has been increasing, due to its hazardous health effects. The purpose of this study was to investigate the concentrations and as well as the inhaled weight of PM, correlated with person's heart rate in subway, bus, vehicle and bicycle in the major public transportation (Sadang - Jamsil and Nowon – Dongdaemun) in Seoul. PM10 exposure were measured from each of transportation means and calculated the average concentrations of PM10 which were 87.2 $\mu\text{g}/\text{m}^3$ for subway, 62.8 $\mu\text{g}/\text{m}^3$ for vehicle, 61.5 $\mu\text{g}/\text{m}^3$ for bus and 53.0 $\mu\text{g}/\text{m}^3$ for bicycle. Actual inhaled weight of PM10 were measured at 56.7 μg for vehicle, 49.4 μg for subway and 44.3 μg for bus. Even though subway had the highest concentration, the highest inhaled weight was 248.1 μg of PM for bicycle. It was due to the long travel time-exposure and breathing rate which leads to maximum of 5.6 times inhaled weight of PM comparing with other modes of transportation. With regards to future studies, the amount of inhalation in each transportation means should be considered in risk assessments of PM.

Condensational growth of aerosol nanoparticles for cell exposure study at air-liquid interface

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Abstract:

In vitro air-liquid interface (ALI) exposure is a rapid and reproducible method to investigate toxicity and health impact of aerosol particles. However, the deposition efficiency (dose yield) depends on the particle size as well as humidity of the carrier gas. In this study, condensational particle growth system was coupled with the ALI exposure system for increasing deposition efficiency of nanoparticles (<100nm). A water condensation growth tube is composed of three parts; preconditioner, initiator, and conditioner with different temperature setting and it was tuned to be operated at the maximum flow rate of 5 L/min. Temperature difference among three parts provides sufficient supersaturation condition for particle growth. To evaluate the collection efficiency (water trap efficiency) as a function of operating parameters (particle size and flow rate), test particles including polystyrene latex (PSL) and inorganic nanoparticles were introduced to the growth tube. Particle growth and collection efficiency was examined using PSL particles and monodispersed NaCl particles (60-200nm). The growth of the test particles was confirmed by the APS. Collection efficiency ranged from 10 to 46% and from 50 to 70% was obtained based on particle number and mass concentration, respectively.

Seasonal variations of organic components in industrial and urban PM_{2.5} of Nanjing and their cell toxicity

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Abstract:

The atmospheric fine particulate matters (PM_{2.5}) impact health significantly, of which organic pollutants are important harmful components. To investigate the spatial-temporal characteristics of organic aerosol compositions and their toxic effects, PM_{2.5} samples from industrial and urban areas of Nanjing city in eastern China were investigated monthly for a year. Organic extracts were analyzed for polycyclic aromatic hydrocarbons (PAHs) and n-alkanes, and exposed to human lung epithelial cells A549 for toxicity by cell viability, oxidative stress, and inflammation. Results showed that the concentrations of PM_{2.5}-bound PAHs and n-alkanes were higher in winter and spring than those in summer and autumn, and their pollution were generally more serious in industrial than urban area. They contribute to the particle cytotoxicity.

Spatio-temporal variations of PM_{2.5} toxicity to A549 cells and the component contributions in a megacity of eastern China

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Abstract:

Atmospheric fine particulate matters (PM_{2.5}) induce adverse human health effects through inhalation, and the harmful effects of PM_{2.5} are determined not only by its air concentrations, but also by the particle components varied spatially and temporally. To investigate these differences, both various components and their toxic effects on human alveolar basal epithelial cells (A549) were analyzed for PM_{2.5} samples collected from different areas of Nanjing city, eastern China during a whole year. Results showed that, spatio-temporal differences of toxicity effects of PM_{2.5} and its components differed significantly, and the PM_{2.5} samples from industrial area showed stronger toxicity. The transition metals in particles, water soluble ions and organic extracts are important contributors to the overall aerosol cell toxicity. Therefore, for reasonable health risk assessments of aerosol pollution, both the inorganic and organic components of PM_{2.5} should be considered.

Assessment of interactions between transition metals and atmospheric organics: Rates of Ascorbic Acid Depletion and Hydroxyl Radical Formation in Organic-metal Mixtures

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Abstract:

Excessive generation of reactive oxygen species (ROS) with the corresponding oxidative stress has been recognized as one important cause for the adverse health effects associated with exposure to ambient particulate matter (PM). Hydroxyl radical ($\bullet\text{OH}$) is the most reactive and perhaps the most damaging ROS, capable of oxidizing most biological molecules. $\bullet\text{OH}$ production in human lung fluids after inhalation of PM can result from redox-active compositions, including transition metals (TMs, e.g. iron and copper) and quinones. Humic-like substances (HULIS) is an abundant fraction of water-soluble organic components in PM. Apart from the redox properties, HULIS is thought to chelate TMs and alter their reactivity considering the common functional groups in HULIS, e.g. carboxylic, phenolic, hydroxyl and amine functional groups. Moreover, reduced nitrogen compounds, such as alkaloids resulting from biomass emissions, may influence the redox reactions of quinones and some reductants in lung fluids (e.g. ascorbic acid).

In this study, we measured the ascorbic acid (AA) depletion and the $\bullet\text{OH}$ formation in binary mixtures of TMs (iron and copper), carboxylic acids, imidazole (derivatives) and quinones in phosphate buffer (pH 7.4) containing AA. Our results show that ascorbic acid depletion rate is not necessarily related to the $\bullet\text{OH}$ formation rate, for example, imidazole (derivatives) facilitated AA loss but almost no $\bullet\text{OH}$ was generated. In addition, carboxylic acids enhanced both AA loss and $\bullet\text{OH}$ formation of TMs, possibly through complexation as effects were only observed with stronger chelators. Moreover, imidazole (derivative) had no impact on iron but suppress the reactivity of copper, and it exerted slight influence on quinones. Similar measurements for mixtures of TMs and HULIS were also investigated.

Our work demonstrates the importance of considering the interactions between components when we evaluate the contribution of individual species to the total oxidative strength. Difficulties encountered in attributing mixture effects to underlying mechanisms suggest that further work in metal-PM organics interactions is necessary in order to acquire a deeper mechanistic insight into the interactions.

Prenatal and Postnatal Exposure to Air Pollution and Children's Health at Two Years Old in the Greater Taipei Area

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Abstract:

Air pollutants pose serious health risks for children. Exposure to air pollution has been associated with various acute and chronic respiratory diseases, as well as inferior neurodevelopment and cognitive functions in children. However, few studies have been conducted in Taiwan to examine the relationships. Therefore, we conducted a study to examine the impact of prenatal and early childhood exposure to air pollution on development and respiratory health of two-year-old children among a birth cohort in the Greater Taipei area. We have recruited 441 cohort children, and evaluated their development and respiratory diseases using standardized questionnaires and Bayley Scales of Infant and Toddler Development. In addition, we selected a part of the study children to conduct indoor and outdoor environmental samplings of their residences to verify their environmental exposure at home. According to our preliminary results, most ambient pollutant concentrations near participants' homes were lower than Taiwan National Ambient Air Quality Standard, except PM_{2.5}, which exceeded the annual average level (15 μ g/m³). Several households had high concentrations of indoor pollutants probably because of low ventilation rates or recent renovation. A few children's bed dust samples contained dust mite allergen levels > 2 μ g/g, which may increase the risk of child sensitization to dust mites. According to multiple regression analyses, child development at two years old was associated with maternal medical histories, length of pregnancy, land use types (e.g., playground and planting fruit trees) near home, NO_x exposure level during second trimester, NO₂ exposure level during 0 - 12 months, as well as PM_{2.5} exposure level during entire pregnancy. Living near provincial roads was associated with children's respiratory diseases. Ozone exposure level during 12 - 24 months and residence near roads and freeways had adverse effects on children's atopy. Overall, air quality and land use types near home are crucial determinants of children's health.

Experimental investigation of inhalation and exhalation flow pattern in a realistic human upper airway model by PIV

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Abstract:

Inhalation exposure of airborne particulate matter (PM) has become a potential threat to human health. The particles pose acute and/or chronic health risks, which may induce respiratory disease such as asthma, cardiovascular diseases, and lung cancer. The flow field pattern in the respiratory tract will greatly affect the particles deposition, especially the micron sized particles. Therefore, an accurate measurement about the characteristics of the air flow field in the human upper airway is an important prerequisite for the study of the movement and transport of particles in the respiratory tract. This study investigated the flow field pattern in the trachea region under oral and nasal inhalation and exhalation in the air for the first time. A realistic three-dimensional human upper airway model was built from magnetic resonance imaging (MRI) scanned images, including the nasal, oral, pharynx, larynx, trachea and part of the first generation of the tracheobronchial tree. The experimental model was 3D printed as 2 times the size of the realistic model for better measurement, with the trachea region made of high borosilicate glass. The respiration flow pattern through oral and nasal in trachea region was measured by the Particle Image Velocimetry (PIV) technique under 3 steady breathing conditions: 36L/min, 64L/min and 90L/min. The flow fields in trachea region during inhalation and exhalation were quite different. The flow inclined to the anterior side of the trachea during inhalation, while during exhalation the flow tended to the posterior side. The flow rates had minor influence on the scalar velocity distribution on the upper trachea. However, the higher the flow rates, the more uniform in the lower part of the trachea. The breathing modes, like oral breathing, nasal breathing or both oral and nasal breathing didn't have much effects on the flow fields in trachea region.

Inflammatory changes of ocular surface by fine particulate matters using eye-only exposure chamber

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Abstract:

According to the recent industrialization and urbanization, air pollution has been identified as a major risk factor for respiratory, cardiovascular, and skin disease and increased morbidity and mortality. Air pollutants cause subclinical inflammation and dryness on the ocular surface. The goal of this study is to evaluate the mechanism of environmental eye disease caused by the exposure to airborne particulate matter (PM) using animal experiment using eye-only exposure chamber. 7-8 week old C57BL/6 mice were exposed with PM_{2.5} and PM₁₀ in two different concentrations, and one mice group were remained with clean air condition. Corneal fluorescein staining and the number of corneal CD11b+ cells were assessed in the different groups. Expression of IL-1 β , IL-6, tumor necrosis factor, and MUC5AC, were evaluated by PCR. TUNEL assay was used to evaluate apoptosis of corneal epithelial cells. From this eye-only exposure chamber experiment, we confirmed that exposure to PM derived PM induced ocular surface damage and inflammation.

This study was funded by the Korea Ministry of Environment (MOE) as “the Environmental Health Action Program (2016001360005)”

Characterizing vertical variation of PM_{2.5} concentrations and compositions at a building in Taipei.

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Abstract:

Exposure to fine particulate matter (PM_{2.5}) may cause multiple health hazards. In many urban areas, people live in high-rise buildings. However, the information on the vertical variation of PM_{2.5} is limited. The aim of this study was characterizing vertical distribution of PM_{2.5} and elemental compositions. A building adjacent to a viaduct in Taipei was selected as the sampling site. A total of 30 daily filter samples were collected at three different floor levels (6m, 24m, and 44m) from March to May in 2018. These samples were analyzed for PM_{2.5}, 16 elements, absorption coefficient and 3 ions. The PM_{2.5} concentrations ranged between 12.3 and 30.1 $\mu\text{g}/\text{m}^3$ during the study period. Sulfate accounted for the largest proportion of PM_{2.5} among the analyzed species with the average concentration of 6.5 $\mu\text{g}/\text{m}^3$. In terms of vertical variations, the highest average concentration of PM_{2.5} was observed at mid-level (18.5 $\mu\text{g}/\text{m}^3$), followed by high-level (18.0 $\mu\text{g}/\text{m}^3$) and low-level floor (17.5 $\mu\text{g}/\text{m}^3$), suggesting the possible influence by the traffic emissions from the viaduct near the sampling site. The results also showed that the components associated with traffic or soil dust were affected by viaducts while no apparent vertical variation was observed for the components associated with long-range transportation. Understanding vertical distributions of PM_{2.5} and the potential causes could be helpful in lower population exposures to air pollution.

Exposure to ambient particles at school and its estimation using fixed site monitors

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Abstract:

Ambient PM_{2.5} concentrations measured at fixed site monitors (FSM) are often biased with respect to exposure concentrations because of spatial variability and infiltration. Based on comparison of ambient concentrations from 14 FSMs and of exposure concentrations measured indoors and outdoors at two schools in Hong Kong for winter and summer seasons, the magnitude and sources of exposure error based on using FSMs as a surrogate for exposure are quantified. An approach for bias correcting surrogate exposure estimates from FSMs is demonstrated. The approach is based on a proximity factor (PF) that accounts for differences in spatial locations, proximity to emissions and deviation from dominant wind direction, and an infiltration factor (IF) that varies by season. The combination of the PF and IF reduce bias in mean school exposure estimates from $\pm 90\%$ to $\pm 20\%$. Bias in exposure estimates from using FSMs as surrogates tend to be smaller for which the exposure site and FSM are aligned with wind direction, have similar sampling height, and are in close proximity. The methodology demonstrated to assess concordance between FSMs and exposure measurement sites can be applied more broadly to help reduce exposure error, which may help to interpret seasonal variations in health estimates.

Keywords: Ambient PM_{2.5}, exposure error, school children, infiltration factor, proximity factor

Development and Evaluation of Low-Cost Sensors for personal PM2.5 Exposure Levels

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Abstract:

Low-cost sensors are being increasingly distributed in the places of interest, not only in ambient but also in indoor environments. The state-of-the-art, small, and inexpensive sensors are being designed for this coming types of environmental researches. The integration of these various sensors has become a new challenge. In this work, we focus on the development of a sensors device, called AS-LUNG, short for Academia Sinica-Lung (the organ affected by air pollutants) to evaluate whether the integrated device is applicable for the daily personal exposure levels.

AS-LUNG integrates low-cost sensors of PM2.5 (Plantower PMS3003), temperature, relative humidity, GPS, and motion. The device is a portable size of 13cm* 6.8cm*4cm with a weight less than 177 g. The choices of 15-sec, 30-sec, 1-min, and 5-min data intervals are given to be used in different study designs. Real-time data can simultaneously be transmitted with the built-in WIFI system back to the cloud database and be recorded to an inserted SD-card for the back-up. The double data storage system gives the convenience to exhibit fine resolution data in time and to avoid data loss.

Performance evaluation of the portable AS-LUNG was conducted in the laboratory. The PM sensor performance is compared to one research-grade instrument (Grimm 1.109 , GRIMM Aerosol Technik Ainring GmbH & Co, Ainring, German) side-by-side in the chamber tests. The results showed linear relationships with good correlation coefficients (0.99 – 0.81) between these two devices over the concentration range of 1-150 $\mu\text{g}/\text{m}^3$. The response of the PM2.5 sensor can be programmed to be corrected based on the regression functions when the data are transmitted back to the cloud database. The prototype of AS-LUNG has been used to examine the exposure levels of commuters in 2016. Based on the pilot studies, our research group has modified the prototype to make the portable AS-LUNG version 1.0 with an on-going effort to improve it.

Traditionally, personal exposure studies were conducted to recruit volunteers to carry heavy and expensive instruments. To convince people to carry the expensive but vulnerable instruments has been difficult in recruitment. Fortunately, the development of the low-cost sensors solves the problem and initiates the new frontier of exposure researches. Our results indicate the low-cost sensors having great potentials for atmospheric aerosol research to assess PM2.5 exposures in high tempo-spatial resolution with much lower costs.

Laboratory assessment of low-cost PM sensors

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Abstract:

Low-cost PM sensors (LCPMS) is now widely used in the field of environmental monitoring owing to their temporal and spatial advantages. The accuracy of them, however, has been challenged continuously, because it is prone to be influenced by refractive index, particle size distribution, number concentration and so on. In this study, a standard aerosol generation system, able to control the mass concentration and particle size distribution, was used to generate the challenge aerosol for performance evaluation of LCPMS. This system was mainly comprised of a syringe pump, a Sono-Tek ultrasonic atomizer, and an aerosol neutralizer (10-mCi Am-241 radioactive source). A TSI 3321 aerodynamic particle sizer was used to measure the aerosol number concentration and size distribution. Six types of LCPMS were tested, which could be divided into two major groups, resistor-type and fan-type, according to the function design.

The count median diameter (CMD) and mass concentration generated by the system were stable. The appropriate CMD is ranging from 0.6 to 1.9 μm , with the corresponding mass concentration ranging from 0 – 450 $\mu\text{g}/\text{m}^3$. The geometric standard deviation of all these size distributions was less than 1.4. The resistor-type sensors showed better performance than fan-type sensors when challenged with micro-meter-sized aerosols (Sensitivity r-type \gg 10% $>$ Sensitivity f-type). The fan-type sensors had better performance when challenged with submicron aerosols (Sensitivity f-type \sim 80%). Lower detection limit (LOD) of sensors also showed similar characteristics, i.e., the LOD r-type increased from 6 to 16 $\mu\text{g}/\text{m}^3$ when size of challenge particle decreased; LOD f-type decreased from 40 to 3 $\mu\text{g}/\text{m}^3$ when size of challenge particle decreased. Furthermore, abnormal position direction of resistor-type sensors could result in poor detection efficiency, but it didn't happen to others, for the fan-type sensors had a more stable air flow inside. The highly linear relationship between the mass concentration measured by LCPMS and the standard mass concentration generated by the system at different conditions could be seen with an average $R^2 > 90\%$. Nevertheless, the bias of these sensors could range from -90% to +300 %, which indicated that the value provided by LCPMS could be far from true concentration. The average mass concentration of NaCl (refractive index was 1.544) measured by LCPMS was higher than that of methylene blue (refractive index was 1.55 - 0.6i), which could be resulted from higher absorbance ability of methylene blue. The response time of LCPMS was normally under 5 min.

In conclusion, the standard aerosol generation system used in this work could provide an ideal PM_{2.5} challenge aerosol environment. It could also be applied to other studies with challenge aerosol size ranging from sub-micrometer to several micro-meter. LCPMS could be useful, for example, when the purpose is to monitor the accidental emission of an industrial park. Other than that, the use of LCPMS data should be very cautious, because the information on accuracy and durability of LCPMS are still very limited.

Performance of Rapid PM_{2.5} Detectors in a Warm Humid Urban Environment

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Abstract:

Low-cost portable sensors of PM_{2.5} concentrations are of emerging wide use and carry various advantages such as easy deployment and providing high time resolution. Nevertheless, the applicability and data validity are questioned because of omitted measurements of ultrafine particles, less than characterized effects of environments (e.g. varied relative humidity), fluctuating concentrations, etc. Such issues are of particular concerns in environments having PM_{2.5} concentrations lower than 50 µg/m³ or fluctuating between low and high PM_{2.5} concentrations because increased or unknown relative errors can disrupt the reliability of resultant concentration trends. This study investigates performance of two types of real-time optical devices (including a commercially available PM_{2.5} sensor) against gravimetric measurements via beta-ray gauge, staged aerosols sampling and standard filter reference methods. All measurements of ambient PM_{2.5} concentrations were conducted in a warm and humid tropical urban environment for a duration of >100 days. Time resolution determines how the data derived from forward laser light scattering of somewhat dehumidified aerosols (at relative humidity of ~50%) deviate from gravimetric measurements. On a 24-hr basis, the optical method underestimates PM_{2.5} concentrations because of underestimation of particles smaller than 300 nm. The underestimation, however, can be corrected using a single factor of 1.60 (n=106) to match with the data yielded from beta-ray gauge. A random trend between data yielded by the optical method vs reference filter-based (24-hour) gravimetric PM_{2.5} concentrations shows substantial impacts of loss of semi-volatile inorganics and volatile compounds. For a 3-hour time resolution, the optical method (10.8±5.7 µg/m³, n=777) significantly underestimates PM_{2.5} concentrations by more than 30% (p<0.01) compared to (16.0±6.8 µg/m³); the larger the gravimetric PM_{2.5} concentration, the more substantial underestimation. Correcting the underestimation is beyond a single factor. When the urban PM_{2.5} concentration was enriched to more than 60 µg/m³ by transboundary peat-forest smoke, the optical

method overestimates the 24-hour concentrations, showing a 2nd order of polynomial trend ($r=0.87$). Compared to the optical method, the commercially available sensors show better correlation with gravimetric measurements with less than consistent deviation. More information will be presented to elucidate effects of environmental relative humidity, diurnal, nocturnal and seasonal trends, as well as concentration-dependent correction methods for practical applications in a warm humid urban environment.

Field Evaluation of Low-cost Plantower PM Sensors at an Urban Site

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Abstract:

Low-cost particulate matter (PM) sensors are widely deployed for hourly PM_{2.5} sampling in the ambient environment to measure the PM_{2.5} concentrations at high spatial and temporal resolution. However, the performance of PM sensors is significantly affected by variations in the ambient relative humidity (RH_a) as well as PM_{2.5} concentrations which is not well understood under field conditions. In the present study, the low-cost PM sensors Plantower PMS5003 and A003 were tested in the field condition with collocated the FEM-designated tapered element oscillating microbalance-filter dynamics measurement system (TEOM-FDMS) during 31 March to 20 April 2017 and Beta-Attenuation Monitor (BAM-1020) during 23 August to 15 September 2018 at NCTU, respectively, to evaluate their sampling performance in the field. The hourly PM_{2.5} concentration measured by the PM sensors (PM_{2.5}, SA003 and PM_{2.5}, S5003) are generally overestimated with the average biases of $+23.00 \pm 49.00\%$ and $+36.58 \pm 35.65\%$ compared to those by BAM (PM_{2.5}, B) and TEOM-FDMS (PM_{2.5}, T: base mode value), respectively. The PM_{2.5} concentrations difference between A003 and BAM (DiffSA003-BAM) and PMS5003 and TEOM (DiffS5003-TEOMb) increases with increasing RH_a which is mainly due to deliquescent growth of particles when RH_a is greater than 60% and lack of heater to reduce the RH_a of the incoming aerosols before PM sensors inlet. In addition, sensors show large detection error and poor correlation at lower PM_{2.5} concentrations.

Therefore, to make these sensors become reliable use, PM_{2.5}, SA003 and PM_{2.5}, S5003 concentrations were calibrated using PM_{2.5} BAM and TEOM as reference. ANOVA was used to get the relationship between PM_{2.5} sensors, PM_{2.5} monitors and RH_a. The effect of RH_a is more pronounced when PM_{2.5} measured by A003 is greater than $20 \mu\text{g m}^{-3}$, while PMS5003 is affected with RH_a for whole range of PM_{2.5} concentrations. An empirical relation (PM_{2.5}, BAM = $0.48 \cdot \text{PM}_{2.5, \text{SA003}} - 0.21 \cdot \text{RH}_a + 22.77$ when $\text{PM}_{2.5} > 20 \mu\text{g m}^{-3}$) for A003 was used to calibrate the PM_{2.5}, SA003. Similarly, two empirical relations (PM_{2.5}, BAM = $0.48 \cdot \text{PM}_{2.5, \text{SA003}} - 0.21 \cdot \text{RH}_a + 22.77$ when $\text{PM}_{2.5} < 40 \mu\text{g m}^{-3}$ and PM_{2.5}, BAM = $0.48 \cdot \text{PM}_{2.5, \text{SA003}} - 0.21 \cdot \text{RH}_a + 22.77$ when $\text{PM}_{2.5} > 40 \mu\text{g m}^{-3}$) for PMS5003 were used to calibrate the PM_{2.5}, SA003. After calibration using empirical relations, the bias between A003 and BAM is reduced from $+23.00 \pm 49.00\%$ to $-2.82 \pm 32.34\%$ with improved R² from 0.73 to 0.84. Similarly, the bias between PMS5003 and TEOM is reduced from $+36.58 \pm 35.65\%$ to $+4.55 \pm 23.53\%$ with improved R²

from 0.77 to 0.80. The different models of PM sensors will be evaluated in future with collocated monitors in field conditions to have better understanding on the performance of PM sensors.

Use of low-cost sensors for ozone pollution monitoring

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Abstract:

With the increasing popularity of low-cost air sensors in recent years, low-cost sensor network systems will play an important role in air quality monitoring. However, there is a problem with the accuracy of the data generated by these monitoring networks. This study used reference instruments to assess the capability of low-cost sensors to measure over time under a range of environmental conditions. A multi-parameter algorithm was used to correct the effects of environmental conditions on electrochemical sensors for ozone (O₃), nitrogen dioxide (NO₂), and nitric oxide (NO). The performance and limitations of low-cost sensors in urban areas affected by traffic in Shenzhen were tested. Low-cost sensors were deployed at three locations in Shenzhen to monitor data to analyze temporal and spatial variations of ozone. The O₃-VOC-NO_x sensitivity and sources of ozone pollution in Shenzhen were also addressed.

Keywords: low-cost sensors, ozone, performance evaluation

Why is Short Time PM2.5 Forecast Difficult? The Effect of Sudden Events

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Abstract:

The existing prediction models for PM2.5 concentration can be classified into longterm models and the short-term ones depending on whether the forecast target is more than one day in the future. Short-term prediction models usually respond slowly to drastic variation in air quality in the presence of sudden events. The purpose of this paper is to figure out the causes behind sudden events. Taichung monitoring data obtained from Airbox project were fed into the current short-term prediction model to acquire air quality forecast for one hour later. The prediction results are then analyzed by our model where event timing is identified. Considering the complexity of sudden events, different data about environment, such as temperature, rainfall, relativehumidity, wind speed and direction, and human activities, like traditional celebration, days-off, commuting, were combined with the sudden event timing to form the basis of our research. After applying Kullback–Leibler divergence and Hierarchy Clustering, the result was analyzed to find the causes of sudden events. In springtime and summertime, unexpected changes in rain and temperature were critical for prediction models. On the other hand, unanticipated changes in intensity of rainfall and wind were important in the autumn and winter. For human activities, crowds of commuters, tourists, and pilgrims have some impact on unusual air quality. We believe the forecast power of short-time prediction models in the face of sudden events will be greatly improved after taking this research result into consideration.

Keywords Low-cost sensors; Internet of Things; Data analysis; PM2.5; Hierarchical clustering

Analysis of PM_{2.5} Concentration in a Small Area Using a Network-based Low Cost Dust Sensors

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Abstract:

Recent increases in fine dust concentrations and non-periodic changes in major cities in East Asia are threatening the health of many people. To solve this problem, Asian countries are making efforts to reduce the concentration of fine dust through various regulations and it is known that the pollution of fine dust of the atmosphere is gradually being improved. Nevertheless, in Korea, high-density fine dust is generated non-periodically, the government regards this as a disaster, and through the forecast, citizens are guided to reduce their life outside or to wear masks. However, the information provided by the government represents a wider area than the observation point, and it differs from the actual living environment. The concentration of residential areas, roads, and factories in metropolitan areas is clearly different. In addition, citizens are increasingly interested in the concentration of fine dust in their cities, as well as in the direct breathing environment. This is evidenced by an increase in sales of air cleaners and personal dust detectors.

In order to monitor the fine dust concentration in a small area, a number of measuring equipment are needed. However, the gravimetric method, the beta-ray attenuation method, and the light scattering-based high-performance instrument used for the fine dust forecast have a limitation in the measurement time and cost. The gravimetric method and the beta-ray attenuation method are difficult to tell the concentration in real time because fine dust collection time is needed, and accurate optical instruments require cost of at least several thousand dollars to tens of thousands of dollars per unit, so there are cost limitations in using many equipment.

For this reason, the use of a low cost dust sensor can be considered. The low cost dust sensor is only a few dollars per unit, so it is less costly to place it in multiple locations. In addition, the accuracy of $\pm 10\%$ to 20% of the reference instrument is sufficient to monitor the fine dust concentration. Samyoung S&C's dust sensor is a PM_{2.5} sensor capable of measuring $0.3 \mu\text{m}$ size particles as LED light source. By installing these low cost dust sensors in multiple locations and collecting data over a network, we can know not only the concentration of fine dust in a small area, but also the distribution and movement characteristics. In this study, a networked dust sensor was installed around the building, and the

characteristics of fine dust concentration in the small area were analyzed from the data collected from these sensors

Aerosol-Based Synthesis of Nickel-based Hybrid Nanoparticle for Methane-Based Energy Applications

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Abstract:

Nickel-based catalysts are widely used in methane-based energy applications. A gas-phase evaporation-induced self-assembly (EISA) method has been developed to synthesize aerosol-derived nanoparticle as the catalyst for the catalysis of (1) steam-methane reforming and (2) dry reforming of methane with CO₂. Here we have successfully fabricated Ni-Al-NP of different Ni/Al ratio through EISA approach. This study employs a material characterization platform consisting of H₂ temperature-programmed reduction (H₂-TPR), X-ray diffraction (XRD), Brunauer, Emmet, and Teller (BET) surface area analysis and CO₂ temperature-programmed desorption (TPD) to study material properties of the Ni-Al-NP. A fixed bed reactor coupled with gas chromatography that equipped with a thermal conductivity detector is used to analyze catalyst activity, selectivity and operation stability of the synthesized catalysts. The results show that the addition of aluminum oxide increases the specific surface area and active metal surface area of the Ni-Al-NP. The presence of aluminum oxide can reduce the extent of sintering of the catalyst during the catalysis. A very high catalytic performance (high turnover frequency, operation stability) achieves toward drying reforming of methane with CO₂. The work demonstrated a facile route for controlled gas-phase synthesis of hybrid nanocatalysts with a mechanistic understanding of synergistic catalysis useful for a further enhancement of methane-based energy applications.

Aerosol Technology For Synthesis of Energy Material

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Abstract:

A facile aerosol-based synthetic approach is demonstrated for the fabrication of silver-manganese oxide hybrid nanoparticle clusters (Ag-MnOx NPCs) as the electrode material of supercapacitor (SC). Thermogravimetric analysis (TGA), scanning electron microscopy (SEM), XRD and in-situ DMA were demonstrated to characterize properties of hybrid nanostructures. Two types of binder solutions, nafion and polyvinylidene fluoride (PVDF), were employed, and the capacitance performance of different types of binders were investigated by cyclic voltammetry (CV) and galvanostatic charge discharge (GCD). The results show that Ag nanoparticles were homogeneously distributed outside the MnOx nanoparticle cluster to form the hybrid nanstructure. PVDF was a more suitable binder than nafion based on its higher dispersibility and better electrochemical performance. The specific capacitance of Ag-MnOx NPC electrode reached 210 F/g, and it was shown to further increase to 325 F/g after the blending of carbon black nanoparticles. This study demonstrates a prototype approach for the fabrication of MnOx-NPCs as the supercapacitors with the enhanced capacitance by the increase of conductivity at nanoscale and micrometer scale.

Surface enhanced Raman scattering of size-selected Si quantum dots

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Abstract:

Size effects on the surface-enhanced Raman scattering (SERS) of silicon quantum dots (Si-QDs, 4 to 12 nm) were investigated. Highly active SERS substrates were prepared by depositing silver nanoparticles generated by a spark discharge method. Silicon nanoparticles (aerosol) were generated by laser ablation of bulk silicon target under the helium background gas. Crystallinity of the silicon nanoparticles were also controlled by the thermal treatment (aerosol post annealing). Si nanoparticles were classified by the low pressure differential mobility analyzer (LP-DMA) and then deposited on the SERS substrate by an impactor. Raman spectrum was obtained using excitation laser with wavelength of 532nm and power of 0.5 mW with changing the size and annealing temperature (crystal structure) of the Si-QDs. Highly enhanced Raman signal was obtained as a function of the size of Si-QDs. Size effect of the enhanced Raman spectrum, i.e. red-shift and peak broadening, was fairly represented by a phonon confinement model. The enhancement factor increase with decreasing annealing temperature, suggesting a strong interaction between excitation laser (532nm) and Si nanostructures.

Gas-phase synthesis of Ni-CeO₂/Al₂O₃ Nanocatalysts for High-Performance reductive amination of polyols

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Abstract:

In this study, we develop a new method to synthesize Ni-CeO₂/Al₂O₃ as high-performance nanocatalyst for synergistic catalysis of reductive amination of polyols. Our work starts from the gas-phase nanoparticle synthesis by the evaporation-induced self-assembly followed by a thermal decomposition at 500 °C and a 2nd stage gas-phase H₂-reduction at 800 °C. Complementary characterization methods, including SEM, EDX, TPR, CO-pulse chemisorption, BET, and XRD were employed to provide materials properties of the synthesized catalysts prior to and after the catalytic reduction amination of polyols. A customized high temperature/pressure reaction system is developed, and the conversion ratio of raw material is measured by titration. The work demonstrated a facile route for controlled synthesis of Ni-CeO₂/Al₂O₃. The mechanistic understanding of synergistic catalysis developed in this study can be used to further enhance activity and improve the operation stability for a variety of reductive amination processes using transition-metal based catalysts.

Microwave Plasma-Enhanced Nanocoatings of Polymethylmethacrylate on Multiwalled Carbon Nanotubes

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Abstract:

Carbon nanostructures coated with foreign substances are promising materials with extensive applications in electrical, optical, and mechanical fields. The nanocoatings are often performed by solid and liquid based methods. However, these methods have several drawbacks such as the use of solvents and volatile materials, high temperatures, and long reaction time; whereas, controlling the progress of reaction is the primary challenge in gas-phase processes. Compared to coatings with metal or metal oxide materials, coatings with polymeric substances require special attention to retain the polymeric structures in the coated substances. This work is focused on experimenting and developing a gas-phase coating process involving polymeric coatings on multiwalled carbon nanotubes (CNTs). Polymethylmethacrylate (PMMA) is tested as the polymeric substance as it finds applications in sensors, optical materials, composites, and allied areas. The coating on CNT surfaces is attempted by a gas-phase plasma-enhanced chemical vapor deposition because this process has advantages such as dealing with a variety of materials, very fast reaction time, single step deposition, and higher growth rates. The system used for the coating is similar to that described by our group for the synthesis of nanoparticle-embedded thin films [1]. Two gas streams containing aerosolized multiwalled CNTs and vaporized methylmethacrylate (MMA) with an initiator are fed simultaneously into a microwave-generated plasma to develop coated CNTs. The coated materials were characterized by Fourier transform infrared (FTIR), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), and transmission electron microscopy (TEM). The effects of process parameters affecting the coating, i.e., monomer and initiator composition, plasma input power, and feed-gas flow rates were studied. FTIR and XPS analysis indicated the formation of polymeric MMA on the CNTs under favorable conditions. FTIR analysis also revealed that neither the breakage of functional groups of the polymeric PMMA nor the destruction of the CNTs occurred during coating. The presence of dominant methyl and methylene groups of polymers was confirmed by XPS, which indicated the polymerization of monomers on the CNTs. SEM observation confirmed uniform and entire surface coatings on the CNTs, with thickness from several tens of

nanometers to several micrometers. Further, TEM observation indicated amorphous PMMA coated on the CNTs.

[1] Kubo, M., T. Taguchi, and M. Shimada, *Thin Solid Films*, 2017, 632, 55-68.

Development of dye-doped silica nanoparticles with controllable size as aerosol tracer particles

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Abstract:

Aerosol tracer particles are widely used for monitoring mass transportation, leakage, particulate pollutants, and so forth. Monodisperse particles with well-controlled size provide convenience for studying phenomena with particle size-dependency. Further, the incorporation of synthetic dyes provides a means to high-sensitivity measurements based on the optical response of dyes such as fluorescence and UV-Vis light-absorbance. Here, we develop dye-doped silica nanoparticles (DSNPs) having controllable size as aerosol tracer particles through sol-gel synthesis. The DSNPs are monodisperse with sizes controllable between 30 nm and 180 nm. A synthetic dye Rhodamine 6G is successfully incorporated into the silica nanoparticles, as indicated by the UV-Vis absorbance of DSNP colloid at ca. 530 nm which is also the characteristic absorbance of Rhodamine 6G. No obvious dye leakage is observed for the DSNPs stored as an aqueous colloid for over half a year, indicating good stability.

ZnO-TiO₂ Core-Shell NWs Decorated with Au NPs for Plasmon-Enhanced Photoelectrochemical Water Splitting

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Chungnam National University

Jinse Park, Sinwook Kang, Jonghun Kim, Weon Gyu Shin

Abstract:

In this study, ZnO-TiO₂ core-shell nanowires (ZT NWs) sensitized with Au nanoparticles (NPs) were synthesized on a Si- wafer via CVD method and photochemical deposition method. Au NPs can act as a plasmonic photosensitizer which can enhance the absorbance in the visible region. As a result, Au decorated ZnO-TiO₂ core-shell NWs showed the enhanced photocurrent density and photoconversion efficiency compared to ZnO-TiO₂ core-shell nanowires.

Wintertime secondary organic aerosol formation in Beijing-Tianjin-Hebei (BTH): Contributions of HONO sources and heterogeneous reactions

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Abstract:

Organic aerosol (OA) concentrations are simulated over the Beijing-Tianjin-Hebei (BTH) region from 9 to 26 January, 2014 using the Weather Research and Forecasting model coupled to chemistry (WRF-CHEM) model, with the goal of examining the impact of heterogeneous HONO sources on SOA formation and the SOA formation from different pathways during wintertime haze days. The model generally performs well in simulating air pollutants and organic aerosols against measurements in BTH. Model results show that heterogeneous HONO sources substantially enhance the near-surface SOA formation, increasing regional average near-surface SOA concentration by about 46.3% during the episode. Oxidation and partitioning of primary organic aerosols treated as semi-volatile dominate the SOA formation, contributing 58.9% of the near-surface SOA mass in BTH. Irreversible uptake of glyoxal and methylglyoxal on aerosol surfaces constitutes the second most important SOA formation pathway during the episode, with SOA contribution increasing from 8.5% in non-haze conditions to 30.2% in haze conditions. Additionally, direct emissions of glyoxal and methylglyoxal from residential living sources contribute about 25.5% to the total SOA mass on average in BTH. Our study highlights the importance of heterogeneous HONO sources and primary residential emissions of glyoxal and methylglyoxal to SOA formation in winter over BTH.

Estimation of Source Location with Potential Source Density Function (PSDF)

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Jiyi Lee, Ewha Womans University

Abstract:

The method of potential source contribution function (PSCF) is widely used to identify the source areas of air pollutants from ambient data and backward trajectories. PSCF runs fast with a simple algorithm; however, its result is highly uncertain, especially in cells with a small number of trajectories. To reduce the associated uncertainty, an arbitrary weighting function is generally applied in PSCF results. However, weighting function cannot reduce the uncertainty completely.

Potential source density function (PSDF) is developed to identify the source areas of air pollutants without any assumption or arbitrary proposition. PSDF also uses the same ambient data and backward trajectories as those for PSCF. However, this model is based on the theory of Gaussian process regression (GPR) which provides a sound theoretical basis and enables quantification of associated uncertainties. PSDF can also semi-quantitatively show the potential intensity of air pollutants' emission in each cell.

In this presentation, the concept of PSDF is described. PSDF is applied to identify source areas for the observed air pollutants in Anmyeon Island (background site) and Seoul, Korea between 2015 and 2018. Furthermore, a brief comparison of the results against that of other methods to identify source location is also provided.

Development of high-resolution real-time air quality forecasting system over northern Thailand

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Kraichart Tantrakarnapa, Mahidol University

Abstract:

Biomass burnings produce aerosols and air pollutants during dry season over northern Thailand and nearby countries in Southeast Asia almost every year. The burning of agricultural residuals and forest fires are the main sources and contribute the significant amount of air pollutants over the region. During the dry season (February-April), fire hotspots detected by MODIS satellites are revealed all over the Indochinese peninsula. Biomass burning pollutants have impacts not only on local air quality but also the public health(people). Many sectors and institutes have been working for coping with this seasonal issue for several years but the issues throughout the region are still common. One of the limitations in addressing this problem in the area is the lack of a comprehensive measuring instrument, which price is quite expensive. In addition, most of the tools are installed in urban areas, while the rural areas, which are close to the emission sources, rarely have this kind of observed tools. Therefore, in this study, the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) model is used as the regional air quality model to forecast the high-resolution real-time air quality and related-meteorological condition over northern Thailand. The biomass burned areas are calculated from the NASA MODIS Near-Real-Time (NRT) active fire hotspots data, and estimated emission rate of pollutants using the 3BEM model to produce the chemical and initial and boundary conditions for WRF-Chem air quality model. Consequently, this experimental air quality forecast model is expected to be the early warning system and play a critical role in research and applications coping air quality impacts and adaptation in northern Thailand.

Source Apportionment of the Atmospheric Fine Particles in an Agricultural Area nearby a Heavy Industrial and Densely City within the Episode Days

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Abstract:

Atmospheric fine particulate matter (PM_{2.5}) is an important index of the background air quality. The local high PM_{2.5} level in the ambient air could be resulted from several reasons, including international long-range transport, local primary emissions, and formation of secondary particles by the (photo-/atmospheric) chemical reaction in the certain meteorological conditions. This research focuses on an agricultural area, which is usually impacted by higher PM_{2.5} levels (40–60 $\mu\text{g m}^{-3}$) during winter, especially several episode days. The potential sources could be attributed to the nearby heavily industrialized and densely urban area. Model-3/CMAQ was utilized to preliminarily estimate the contributions of primary and secondary PM_{2.5} from the nearby cities and counties. Three sampling sites were then set up for collecting the PM_{2.5} data for their chemical components (9 ions, 15 metals, 16 polycyclic aromatic hydrocarbons, and organic and elemental carbonaceous). Chemical mass balance (CMB) model was then employed to analyze the contributions from various sources. The 3D-inverse trajectory model was also used to evaluate the historical 72-hour trajectory of pollution. Results show that the locally higher levels of PM_{2.5} occurred under the influence of anticyclonic outflow, slightly occasional monsoons, warm front, and ante typhoon periods. The major chemical species in PM_{2.5} were sulfate, nitrate, sodium, chloride, potassium, and organic carbonaceous. CMB results showed that the agricultural open burning emission could be one of the important sources, while the secondary aerosols derived from the sulfur dioxide and nitrogen oxides, being emitted from the upwind metallurgical industries, incinerators, coal and fossil fuel furnaces, and local traffic emissions. The inverse trajectory modeling pointed out the southeastern China, Indochina, the western and northern industries and cities to the target area. Consequently, the control strategy should include the prohibition of open burning around the agricultural area, the inter-jurisdiction restringing emission standards, development of local electricity generation and supply system, promotion of greener vehicles and transportation.

Source Apportionment of PM_{2.5} and Organic Carbon Using Comprehensive Aerosol Speciation including Primary and Secondary Organic Aerosol Tracers: A Case Study in Beijing, China

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Abstract:

We conducted a comprehensive chemical speciation study of PM_{2.5} collected from Changping, a suburban district in Beijing over one-year period to identify and quantify major sources of PM_{2.5} and organic aerosol (OA). In particular, more than 115 organic compounds including both primary and secondary OA (POA and SOA) tracers were quantified, together with major ions, elements, elemental carbon (EC) and bulk organic carbon (OC). The OC fraction was broken down on the basis of water solubility and hydrophobicity. A more representative organic matter (OM) to OC ratio (1.7) was determined and enables to estimate total OA mass that accounted for 31% of PM_{2.5}. Source apportionment of PM_{2.5} and OC were performed using positive matrix factorization (PMF) based on the comprehensive data set. Ten factors were resolved including five secondary sources, i.e. secondary sulfate, secondary nitrate, and three SOA sources (SOA I, II and III, identified by corresponding SOA tracers, i.e. isoprene SOA tracers, β -caryophyllene SOA tracer and toluene SOA tracer, respectively). Five secondary sources contributed to 60% of PM_{2.5} and 44% of OC, respectively. For primary sources, vehicle emission, cooking emission, biomass burning and dust contributed evenly to PM_{2.5} (8-10% from each source), while the former two contributed much higher to OC (23-25%) than other primary sources. Pollution event analysis indicated that high concentrations of PM_{2.5} normally corresponded to predominant secondary formation processes. Furthermore, PM_{2.5} and OC on low pollution days were mainly contributed by primary combustion sources while secondary formation pathways gradually overtook on high pollution days. This work helps enhance the understanding of SOA formation and evolution in urban atmosphere. It demonstrates that source identification with inclusion of source-specific organic tracers could greatly improve source separation by receptor models.

Characterization of Carbonaceous Species and Water Soluble Ions in PM 2.5 Collected at Chiang-Mai, Bangkok, and Phuket, Thailand

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Abstract:

Owing to the rapid industrialization and motorization in Thailand, the issues regarding PM_{2.5} pollution have received attention. Moreover, biomass burning will be one of the significant contributors in the agricultural region. In order to identify the potential sources of PM_{2.5} and estimate their contributions, we focused on the characteristics of carbonaceous species and water soluble ions in PM_{2.5} collected at Chiang-Mai, Bangkok, and Phuket, Thailand.

PM samples (72-hours/sample) were continuously collected at each site from March 2017 to March 2018, and chemical analysis was performed. Carbonaceous species (OC and EC) were analyzed by thermal optical reflectance method and water soluble ions (F⁻, Cl⁻, NO₂⁻, NO₃⁻, SO₄²⁻, Na⁺, NH₄⁺, K⁺, Mg²⁺, and Ca²⁺) were analyzed by an ion chromatography.

Characteristic difference was found in OC/EC ratio among the sites. Higher OC/EC ratios were found at Chiang-Mai (6.44 ± 2.90) and Phuket (6.24 ± 2.77) and lower ratio was found at Bangkok (3.30 ± 1.28), suggesting that there are big differences in source contribution at each site. Concentrations of ionic species were typically high in Bangkok as compared with Chiang-Mai and Phuket.

Factor analysis was performed and 4-factor solution (F1: Combustion, F2: Sulfate, F3: Sea salt, F4: Nitrate/Automobile) was resolved. In Bangkok, concentration of species total showed good positive correlations with scores of factors 1 (Combustion) and 2 (Sulfate). Weak correlation was also observed with score of factor 3 (Sea salt). Higher contribution of factor 4 (Nitrate/Automobile) was observed as compared with the other sites. In Chiang-Mai, concentration of species total showed good positive correlations with scores of factor 1 (Combustion) and 2 (Sulfate). No significant correlations were observed with the scores of factor 3 (Sea salt) and factor 4 (Nitrate/Automobile). In Phuket, concentration of species total showed good positive correlations with score of 2 (Sulfate). Weak correlation was also observed with score of factor 3 (Sea salt). Higher contribution of factor 3 (Sea salt) was observed as compared with the other sites.

In the presentation, we will discuss about the difference in the dominant sources at each site by gathering the knowledge obtained in this study.

Impacts of hazardous metals and PAHs in fine and coarse particles with long range transport on Taipei city

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Abstract:

This study assessed the impact of air quality and health risks resulted from ambient PM_{2.5-10-} and PM_{2.5}-bound metals and PAHs in terms of the long-range transport (LRT) in the Taipei City, Taiwan. Multivariate methods with receptor measurements of particles were used to quantify the effect from LRT. The HYSPLIT backward trajectory in cooperation with potential source contribution function (PSCF) was utilized to distinguish LRT aerosol. The annual increased level of LRT (AIRLRT) and associated source contributions in the concentration and resultant health risk were evaluated using a General Linear Model (GLM) with a marginal mean and positive matrix fraction (PMF). LRT in fact influenced fine-sized metals and PAHs rather than coarse-sized aerosols. We found PM_{2.5}-bound toxic trace metals (Pb, Cd, and As) and PAHs (BaP and DBP) could be increased by 90% with an LRT influence in 2014, while AIRLRT in 25% for PM_{2.5} mass concentration was observed. Overall the excess cancer risk (ECR) resulted from metal and PAH exposures was 1.01×10^{-4} , in relation to coal combustion (20.7%), traffic-related emission (59.7%) and re-suspended aerosol (19.6%). Among these contributors, the cancer risk attributable to LRT-related metals and PAHs was enhanced as 25.2%.

Simulated and observed gas-particulate phase PAHs at Noto and Beijing in 2017

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Associated Processor

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Abstract:

Polycyclic aromatic hydrocarbons (PAHs) are regarded as persistent organic compounds which is emitted by incomplete combustion process from fossil fuel, vehicles, and biomass burning. PAHs are highly concerned because of carcinogenic and mutagenic properties. Although the reaction of hydroxyl radical and ozone cause to shorter lifetimes from several hours or days for PAHs in the atmosphere, particulate PAH undergo long-range transport in the atmosphere. Investigating gas-particle partitioning, particularly less than 4 rings substances, is important to understand the long range transport of PAHs.

In this study, we investigated the gas-particle partitioning of PAHs by using two different gas-particulate partitioning scheme, Junge-Pancow (JP) model and Iannelli (LL) model in regional chemical transport model, Regional Air Quality Model (RAQM-POPs). As preliminary results, in RAQM-POPs, gas phase Pyr simulated by JP model are 5-50% larger than those simulated by LL model over the land. On the contrary, gas phase Pyr simulated by LL model are smaller than those simulated by JP model over the North Pacific Ocean.

Furthermore, we investigated the gaseous and particulate phase PAH concentrations at Beijing, China, and Noto, Japan, in spring and summer seasons in 2017. The observation of gaseous and particulate phase PAHs were conducted at spring and summer seasons (Beijing; August 30 to September 6, 2017; Noto; August 30 to September 5, 2017). Gaseous and particulate samples were collected by using High volume air sampler. Particulate phase PAHs were divided into two, PM₁₀ and PM_{2.5}, respectively. It is noted that concentrations of PAH in PM₁₀ were below the detection limit. This indicates that PAH is dominantly existed in PM_{2.5}.

At Beijing in spring season, 4-ring PAHs such as Fluorene (Flu), Pyrene (Pyr), and Crysene (Cry) were detected in gas-phase PAHs. Gas-phase Flu and Pyr concentrations were larger than those in the particulate phase, whereas gas phase Cry concentrations were smaller than those of particulate phase.

In spring season, gas-particulate partitioning ratios were about 0.6 for Flu and Pyr, 0.2-0.3 for Chr, respectively. At the presentation, we will discuss about the comparison of observation and simulated results in more detail.

Multi-constituent data assimilation with WRF-Chem/DART: potential in adjusting anthropogenic emissions and improving air quality forecast over the eastern part of China

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Nanjing University

Tijian Wang, Nanjing University

Arthur Mizzi, Colorado Department of Public Health and Environment

Jeffrey Anderson, National Center for Atmospheric Research

Abstract:

In order to improve the air quality forecast over the eastern part of China, multi-constituent data assimilation (DA) are carried based on the Weather Research and Forecasting Model with chemistry/Data Assimilation Research Testbed (WRF-Chem/DART) chemical transport forecasting/data assimilation system. The system assimilates surface in-situ observations of sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), carbon monoxide (CO), particulate matter with diameter less than 2.5 μm (PM_{2.5}) and 10 μm (PM₁₀) and satellite aerosol optical depth (AOD) to adjust related anthropogenic emission as well as chemical initial conditions (CICs). Validation is based on evaluating prediction skill of 72 h forecasts with adjusted emission. Results show that updated emission improves the model forecasts of each species verified: up to about 25%, 65%, 35%, 30% and 10% root mean square error (RMSE) reduction for SO₂, NO₂, PM_{2.5}, O₃ and CO respectively. Particulate matter with diameter between 2.5 and 10 μm (PM_{2.5-10}) is only slightly improved for limited anthropogenic contribution to it. Time interval adapted to update CO emission is found to be a sensitive factor by comparing experiments with different update interval. Also, NO₂ forecast keeps similar RMSE level but shows lower spatial correlation when NO₂ observations are not assimilated, indicating the value and limitation of O₃-NO_x (nitrogen oxides) cross-variable relationship.

Primarily driven particle pollution: aerosol composition, source and evolution during winter time in Guangzhou, China

Junchen Guo

Sun Yat-sen University

ShengZhen Zhou, Sun Yat-sen University

Weiwei Hu, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Yele Sun, Institute of Atmospheric Physics, Chinese Academy of Sciences

Jun Zhao, Sun Yat-sen University

Abstract:

Abstract. aerosol pollution is a significant environmental issue with wide attention from both Chinese government and public, for its complicated health effects on human beings and far-reaching influences on climate change through radiative forcing. To investigate feature of aerosol pollution in Guangzhou, a field measurement was conducted in Guangzhou Institute of Geochemistry, Chinese Academy of Sciences during winter time from 20 November 2017 to 5 January 2018, with an Aerodyne Aerosol Chemical Speciation Monitor (ACSM) and various collocated instruments. Surrounded by several traffic arteries, the unique location makes it a perfect site to characterize typical city aerosol pollution. The results suggest that non-refractory submicron aerosol (NR-PM₁) vary dramatically as clean episodes and polluted episodes alternate during measurement. NR-PM₁ correlates well with PM_{2.5} on condition of $R_p=0.7$ and contribute 90% mass concentration to PM_{2.5} for the entire study, making it the most important component of fine particles. Fraction of organics enhance from 45% to 53% as clean episode switches to polluted episode, indicating its remarkable role in NR-PM₁ even for clean period. The characteristic diurnal behaviors of all NR-PM₁ species present a common trend that secondary particle matter (SPM, include nitrate, sulfate, ammonium, SVOOA, LVOOA) have a flatter diurnal cycle than primary particle matter (PPM, include chloride, HOA, COA), implying the noticeable effect of photochemistry. 8 species of NR-PM₁ (nitrate, sulfate, ammonium, chloride, LVOOA, SVOOA, HOA, COA) are gathered into 10 bins of NR-PM₁ mass concentration to figure out their evolution as a function of NR-PM₁ mass concentration. It is suggested that SPM almost linearly increase or even increase slower at high NR-PM₁ mass concentration, while PPM sharply grows at mass range of 40-90 $\mu\text{g m}^{-3}$, indicating potential promotion of PPM for pollution events. It's interesting to notice that only COA has even a higher growth rate at mass range of 90-110 $\mu\text{g m}^{-3}$, revealing its significant contribution to extreme polluted period. Little differences were presented between week days and weekend for average mass concentration while weekend diurnal variation indicates reduced human activities in the morning and enhanced human activities in the afternoon compared to week days. Positive matrix factorization was

performed on ACSM OA mass spectra, and identified four factors, i.e., hydrocarbon-like OA (HOA), cooking OA (COA), semi-volatile OOA (SVOOA), low-volatile OOA (LVOOA). HOA and COA represent local primary source such as traffic emission and cooking activities, SVOOA and LVOOA formed through a series of secondary process like photochemistry or gas/particle partitioning. SVOOA shows similar diurnal cycle to nitrate with a pronounced peak at morning, which imply the potential influence of temperature on gas/particle partitioning. This study will further compare clean period and 5 pollution events to extract different feature and local mechanism of NR-PM1.

The Impact of Particulate Matters on the Formation and Chemistry of Tropical Heavy Rain Accompanied by Squall

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Abstract:

In recent years, the number of sudden and locally-distributed heavy rains (over 50 mm/h) has increased in urban areas during summer (hereafter, Urban heavy rainfall: UHR), just like tropical heavy rain accompanied by squall (hereafter THRS). Urban flood disaster due to UHR is a big concern not only in Japan but also in the other industrial countries. However, it is difficult to predict when and where the UHR forms because the formation mechanism is not clear yet. The rise in temperature due to the urban heat island phenomenon and global warming leads to a transition from temperate to tropical in the Tokyo metropolitan area and could cause the formation of UHR in addition to urban air pollution. On the other hand, in Southeast Asia, where air pollution is now becoming severe, THRS frequently occurs. Therefore, to clarify similarities and differences by comparing UHR in the Tokyo metropolitan area, which is approaching the tropical climate, and THRS in Southeast Asia, where air pollution is progressing in the tropical climate, could make clear the formation mechanism of UHR.

We will firstly report the current status of air pollution and the chemistry of THRS in Siem Reap, Cambodia, which is located at the northern tip of Tonle Sap Lake and famous as the gateway of the Angkor monuments. In recent years automobile including tuk-tuk with tourists has been rapidly increasing. There is concern that the progress of air pollution could cause the deterioration of Angkor monuments.

We conducted observational campaign in Siem Reap in rainy season and in dry season. PM_{2.5} and black carbon aerosol (BC) mass concentration in the ambient air were measured by handy monitor every minute. We collected SPM samples onto a quartz filter with high volume air sampler in the day time and in the night time and 41 trace metals were measured by ICP-MS. VOCs (chlorinated hydrocarbons, mono and di aromatic hydrocarbons), gaseous elemental mercury (GEM), acidic gases (SO₂, HNO₃, and HCl), NH₃, and water-soluble aerosol components such as sulfate and nitrate were also measured. We observed 4 events of THRS during the campaign and sequentially collected rainwater every 2-10 minutes

from the beginning. Major inorganic ions and trace metals were measured with stable isotope ratios of hydrogen and oxygen.

A spike peak of PM_{2.5} (from 22 to 73 $\mu\text{g}/\text{m}^3$) was observed with a sharp drop of air temperature (from 31.3 °C to 23.0 °C) 25 minutes before the THRS on September 6th in 2018. BC concentration similarly changed with PM_{2.5} almost during the observation period, but a spike peak of BC was not observed 25 minutes before the THRS. This result indicates that the secondarily formed aerosols such as sulfate, nitrate, and organics other than BC affect the formation of THRS. In the poster presentation, we will discuss about the impact of particulate matters on the formation and chemistry of THRS based on the results of chemical and stable isotopes analysis.

The contributions of short-lived climate forcers to global climate change since the pre-industrial era

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Abstract:

Short-lived climate forcers (SLCF) are important contributors to anthropogenic climate change. We used an online aerosol–climate model (BCC_AGCM2.0_CUACE/Aero) to simulate effective radiative forcing (ERF) and climate response to changes in SLCF concentrations, including methane, tropospheric ozone, and black carbon, from the pre-industrial era to the present (i.e., the period of 1850–2010). The global annual mean ERF due to SLCF was 0.99 W m^{-2} . Increased SLCF concentrations led to warming effects over most parts of the globe, with the most obvious warming occurring in the mid-high latitudes of the Northern Hemisphere (NH) and the ocean around Antarctica, showing increases reaching 1.0 K. The changes in annual mean surface air temperature (SAT) were more prominent in the NH than in the Southern Hemisphere (SH), at 0.72 and 0.68 K, respectively. Precipitation increased by about 0.10 mm d^{-1} in mid-high latitudes and decreased by about 0.20 mm d^{-1} in subtropical regions. There was a northward shift in the Intertropical Convergence Zone due to the interhemispheric asymmetry in SAT, which was an adverse effect of aerosols. Changes in SLCF concentrations caused increases in global annual mean SAT and precipitation of 0.70 K and 0.02 mm d^{-1} , respectively. SLCF had little effect on global average cloud cover, but there were obvious regional changes. Low cloud cover increased by about 2.5% over high latitudes in the NH and the ribbon area near 60°S , whereas high cloud cover increased by more than 2.0% over northern Africa and the Indian Ocean. We also compared the contributions of SLCF and carbon dioxide (CO_2) to radiative forcing and global and regional warming. During 1850–2010, the SLCF ERF was equivalent to 33, 83, and 50% of the CO_2 ERF in global, NH, and SH terms, respectively. The increases in SAT caused by SLCF corresponded to 43 and 52% of the warming effects due to CO_2 globally and in China, respectively.

Water-soluble ions and oxygen isotope in precipitation over the Qinghai Lake area in northeastern Tibetan Plateau, China

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Abstract:

A total of 30 precipitation samples were collected at a remote site of Qinghai Lake in the northeastern Tibetan Plateau, China, from June to August 2010. All samples were analyzed for major cations (NH_4^+ , Na^+ , K^+ , Ca^{2+} , and Mg^{2+}) and anions (F^- , Cl^- , NO_3^- , and SO_4^{2-}), electric conductivity (EC), pH, dissolved organic carbon (DOC), and oxygen isotopic composition ($\delta^{18}\text{O}$). The volume-weighted mean (VWM) values of pH and EC in the precipitation samples were 7.2 and $19.0 \mu\text{s cm}^{-1}$. Ca^{2+} was the dominant cation in precipitation with a VWM of $116.9 \mu\text{eq L}^{-1}$ ($1.6\text{--}662.9 \mu\text{eq L}^{-1}$), accounting for 45.7% of total ions in precipitation. SO_4^{2-} was the predominant anion with a VWM of $32.7 \mu\text{eq L}^{-1}$, accounting for 47.1% of the total anions. The average precipitation DOC was 1.4 mg L^{-1} , and it shows a roughly negative power function with the precipitation amount. The values of $\delta^{18}\text{O}$ in the rainwater in Qinghai Lake varied from -13.5‰ to -3.9‰ with an average of -8.1‰ . The enrichment factor analysis indicates that crustal materials from continental dust were the major sources for Ca^{2+} . The high concentration of Ca^{2+} in the atmosphere played an important role in neutralizing the acidity of rainwater in Qinghai Lake area. Cluster analysis of air-mass trajectories indicates that the air masses associated with northeast and east had high values of NH_4^+ , SO_4^{2-} , and NO_3^- , whereas large Ca^{2+} loading was related to the air mass from west.

Keywords: Precipitation chemistry, water-soluble ions, dissolved components, enrichment factor, Qinghai Lake

PCDD/F scavenging by cloud/fog water at Mt. Bamboo during northeast monsoon

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Abstract:

This study investigated PCDD/Fs Scavenging by cloud/fog water. Two passive fog collectors were deployed to collect cloud/fog water at an isolated peak on Mt. Bamboo (1103 m a.s.l) in northern Taiwan during northeast monsoon. The passive fog collector which was operated on the roof of a building at 4 m above ground had two concentric rows of Teflon strings (total number 440, 1.5 mm diameter) with an average spacing to each other (center-to-center) along the circular path of 6.9 mm. Sequential cloud/fog water samples were collected for each cloud event during January 17th to February 24th, 2018 by using passive fog collectors placed next to each other. The two individual cloud water samples were combined into one to reach 20 liters for PCDD/F measurement due to the low solubility of PCDD/Fs in water. A total of ten cloud/fog water samples were collected in this study, and the sampling time for each cloud/fog water samples ranged from 16 hours to 105 hours, with a mean of 46 hours. The PCDD/F concentrations in these cloud/fog water samples ranged at 0.12 ~ 1.72 pg WHO-TEQ/L, with a mean of 0.65 pg WHO-TEQ/L. There are two forms of scavenging ratios, and the first one is defined as $C_{\text{cloud}}/C_{\text{air}}$, where C_{cloud} is the PCDD/F concentration in cloud/fog water (pg/m³) and C_{air} is the PCDD/F concentration in ambient air (pg/m³). The obtained scavenging ratios of PCDD/Fs ranged from 7720 to 168000, with a mean of 93600, which were larger than the scavenging ratios of precipitations (around 105). The second form of scavenging ratios of PCDD/Fs by cloud/fog water is defined as $C_{\text{cloud}}/C_{\text{air}} * \text{LWC}$. The obtained scavenging ratios of PCDD/Fs ranged from 0.003 to 0.07, with a mean of 0.04, which is comparable to the scavenging ratios of trace elements (0.11-0.56). The calculated scavenging ratios of PCDD/Fs by cloud/fog water are crucial for clarifying the effect of cloud/fog water on the deposition of atmospheric PCDD/Fs transported from the East Asian continent to Taiwan, which may be an important mechanism for PCDD/Fs deposition in Taiwan.

Method Study on Filter-loading Effect compensation of Black Carbon Mass Concentration Observation in Regional Atmospheric Background

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Abstract:

Black carbon (BC) aerosols play an important role in local and global climate effects. Based on one-year comparison of BC aerosol observation by optical attenuation technique at Linan station, Zhejiang Province, which is the regional atmospheric background Observatory in China, the differences of two filter-loading compensation methods have been analyzed on the variation concentration and the seasonal characteristics of background BC aerosol in East China. Main findings include: BC mass concentration measured by dual-spot aethalometer is 10%-20% higher than that of single-spot aethalometer. Combining the two filter-loading effect compensation algorithms, the observed results shows a very good linear agreement.

Development of a dust aerosol height retrieval algorithm using the O₄ absorption based on space-borne measurements

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Abstract:

In this present study, we introduce an improved retrieval algorithm for Dust Peak Height (DPH) from O₄ absorption at 477 nm based on satellite based measurements. Here, we tried to improve the algorithm by applying O₄ Air Mass Factor (AMF) to consider the both variations of O₄ Slant Column Density (SCD) and O₄ Vertical Column Density (VCD). Temperature-dependent O₄ cross section is used when constructing Look Up Table (LUT) of O₄ AMF to reduce discrepancy between measured O₄ AMF and simulated O₄ AMF. The main algorithm consists of two sub-algorithms (spectrum fitting algorithm and O₄ VCD calculation algorithm) and a LUT of O₄ AMF. Some filtering parameters on LUT, which can affect on O₄ AMF, are determined by sensitivity test between O₄ AMF against the parameters: O₄ VCD, geometries, surface reflectance, Aerosol Optical Depth (AOD), and aerosol height. Especially, several O₄ VCDs are used in the LUT as O₄ VCD depends on temperature, pressure, and terrain height. The LUT of O₄ AMF is constructed based on the radiative transfer simulation. Inappropriate O₄ VCD assumption can lead to DPH uncertainties more than 89% in dust source region like Gobi Desert (surface altitude > 1 km) in Northeast Asia. The algorithm shows a good performance between true DPH and retrieved DPH (Root mean bias = -0.04 km) in blind test using the Ozone Monitoring Instrument (OMI) synthetic spectrum. We also attempted to retrieve DPH height using the hyperspectral L1B data measured by OMI in Northeast Asia. The DPH retrieved from OMI L1B data (DPH_{OMI}) is compared with DPH measured by National Institute for Environmental Studies (NIES) lidar measurements (DPH_{NIES}). Mean Bias and percent difference between retrieved DPH_{OMI} and DPH_{NIES} are calculated as 0.15 km and 22%, respectively.

Cloud screening method using direct solar irradiances of the sky-radiometer

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Abstract:

Aerosol is one of the most important substances affecting the radiative balance of the Earth. However, their impact on climate has a lot of uncertainty. In order to understand their impact, it is necessary to observe an extinction coefficient of a direct solar irradiance from the ground. The sky-radiometer is used to measure an extinction from top to bottom of the atmosphere, however, the clouds present in the path for sun direction prevent the observation of aerosols. In this study, we developed the new screening method of cloud-affect data using the sky-radiometer.

We developed the new method of cloud discrimination based on the visual observation and the observation of the sky-radiometer (Prede Co. Ltd.) at 400, 500, 675, 870, and 1020 nm in wavelength from May 2017 to March 2018 at the rooftop of the Tokyo University of Science (35.70°N, 135.74°E, 60 m a.g.l.). We obtained aerosol parameters, which are aerosol optical thicknesses at each wavelength (AOT), the Ångström exponent at 400 - 1020 nm (α), the atmospheric turbidity coefficient (β), and the determination coefficient of Ångström law, from the sky-radiometer. Since clouds distribute inhomogeneous and move fast, aerosol parameters quickly change with the cloud-affect data. Therefore, our method was made from combination of the standard deviation and the coefficient of variation in addition to these parameters. Cloud distribution in the whole sky and the sun direction was also visually observed at 9:00, 12:00, and 15:00 LST.

The new screening methods were developed using several combinations of the criteria which was made from above parameters and performed the sky-radiometer measurement at 9:00, 12:00, and 15:00 LST. During the observation period, observations on 271 days (666 samples) were conducted and 54.7% of all samples were affected by clouds. In the result, 10 screening methods were made from above parameters and compared. For example, the first method (M1) used the determination coefficient, the coefficient of variation of α and the standard deviation of β and the second one (M2) used only the determination coefficient and the standard deviation of β . These methods (M1 and M2) distinguished correctly in 73.2% and 88.4% of all data and screened 98.6% and 94.2% of the cloud-affect data,

respectively. In the results, the best method was M1 since this method was most accurately screening the cloud-affect data.

A new method for estimating the noise scale factor (NSF) and random errors in lidar observations

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Abstract:

The noise scale factor (NSF) is useful in calculating the random errors that induced by shot noise of detectors. A new method is proposed for estimating the NSF of lidar systems. Instead of the solar background employed in the conventional method that demands additional experiment or devices, the new method utilizes the Rayleigh backscatter fragments of routinely observed lidar signals to extract the light intensity and shot noise. By experiments, the conventional method resulted in a NSF value of 0.637 with a relative uncertainty of 3.1%. While the NSF estimated by the new method is 0.630, with a relative uncertainty of 5.2%. The experiment results certified the feasibility and efficiency of the new method. Then the random errors and signal to noise ratios (SNR) of lidar signals are computed with the measured NSF, compared with the results calculated from a sequence of lidar profiles, the method using NSF overcomes the interference of aerosols and clouds.

Effect of Strap Tension on Filtering Facepiece Respirator Fit

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Abstract:

1 INTRODUCTION

The tightening of the respirator straps is an efficient way to obtain an adequate face seal, the effect of strap tension on FFRs fit is seldom reported because most FFRs are available with fixed strap lengths. Therefore, the present study aimed to characterize how factors including the match between the 3-D dimensions of the respirator and the wearer's face, the strap tension exerted, the elastic properties of the subject's face skin, and the strength of the infrastructure of the FFRs affecting fit performance.

2 METHODS

In the present study, the standard Chinese head-forms (small, medium, large), made of polylactic acid, were fabricated using a 3-D printer. The tensions of straps under different exertion were measured using a force gauge (Handy Digital Force Gauge, Algol, HF-5, Japan) sit on a linear sliding guide. In addition, the effect a comfort sealing lip and a 3-D silicon lip cushion on FFRs fit was also investigated. A condensation particle counter (PortaCount, TSI Inc., St. Paul, MN, USA) was used to measure the particle concentration inside and outside the FFR. At least five replicates were conducted for each test.

3 RESULTS

For a typical FFR strap, the strap tension rapidly decreased with time from 4.6 to 3.5 N in the first one hours, and, in the first 20 minutes, the tension will have the most dramatic changes. The decreasing trend lessened after the drastic change period. So, the experiment would be measured by 20 mins as a cycle. The continuing fit testing on the head-form showed that not only the strap tension decreased, but the fit factor also decreased. During mannequin test, the fit factor decreased with time, which might be the main due to the lower strap tension. And, In the first 10 minutes, the fit factor will have the most dramatic changes. So, the fit testing would be measured after donning 10 mins. During mannequin test, donning an unsuitable mask cannot increase the Fit Factor by adjusting the strap tension. The results showed that there were optimal tension ranges for upper straps (2.1~2.5 N) and lower (1.9~2.3 N) when the mask equipped with comfort sealing lip. If the mask didn't equipped with comfort nose clip, it can't provide a constant respiratory protection.

4 CONCLUSIONS

The fit test should be performed only for the subject wears the mask for at least 10 minutes. The tensions of upper and lower straps are about 2.21~5.10 and 0.70~5.57 N, respectively. During mannequin test, the results showed that there were optimal tension ranges for upper straps (2.1~2.5 N)

and lower (1.9~2.3 N) when the mask equipped with comfort sealing lip. If the mask doesn't fit the face, then adjusting the strap tension may not meet the required. If the respirator shape has a good fit to the wearer's face, less strap tension is needed. Generally speaking, if the mask didn't equipped with comfort nose clip, particle may be leak from nasal bridge.

Comparison of PM_{2.5} chemical composition collected with Cyclone and Filter

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Abstract:

Atmospheric PM_{2.5} is seriously concerned for human health effects. However detailed mechanism of the cellular biochemical reactions associated with toxicity of PM_{2.5} have not been revealed so far. Therefore we would like to conduct biochemical experiments associated with PM_{2.5}. In order to study the toxicity of PM_{2.5}, we have to collect atmospheric PM_{2.5} samples.

Possible methods for collecting PM_{2.5} samples are filter and cyclone. Generally, filter method is a conventional way to collect PM_{2.5}. However, filter method has a problem that PM_{2.5} collected with the filter may not be the same as those present in ambient air due to artifact. In addition, the amount of particles that are collected on a filter is often insufficient to perform exposure studies. On the other hand, the principle of cyclone method is centrifugal force to the PM_{2.5}. The samples were collected in the bottle. Therefore it is possible to avoid artifact because samples were not on the line of air flow. In addition, with the cyclone, samples can be collected in large quantities as powder form. Therefore we developed an instrument that collects PM_{2.5} in the air using the cyclone. This instrument can collect approximately hundreds mg of PM_{2.5} as powder form for 2 ~ 3 weeks sampling. And there is a report that influence of the powder form samples is remarkable as compared with the case that the extract from the filter is exposed when performing the biological exposure experiment. Therefore we use the samples collected with the cyclone for biological exposure experiment. This presentation shows the chemical composition characteristics of samples which collected with the cyclone and with the filter quantitatively.

The powder form samples collected with the cyclone and the sample collected with the filter were analyzed by ion chromatography. As a result, the cyclone collection efficiency of the NH₄⁺, SO₄²⁻ and K⁺ was less than 7 % when the collection efficiency of the filter sample was defined 100 %. Generally, NH₄⁺, SO₄²⁻ and K⁺ are distribute much smaller range of PM_{2.5} compared to other components. Therefore these components were underestimated because of the separation performance of the cyclone. On the other hand, NO₃⁻ in the powder form samples collected with the cyclone was 1.5 to 6 times higher than that of the filter samples. This suggested that NO₃⁻ was probably underestimated by filter collection. In order to confirm this, a surrogate experiment was carried out. Ammonium nitrate solution was dropped onto the filter and cyclone bottle and dried. After that clean air were passed there

for a week and the loss of NO_3^- were measured. As a result, it was revealed that NO_3^- on the filter were lost about 20 % during the experiment.

Performance Evaluation of Personal/Portable Air Cleaners

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Chih-Wei Lin, National Taiwan University

Sheng-Hsiu Huang, National Taiwan University

Abstract:

Indoor air cleaners are commonly used as an adjunct to source control and ventilation. In ANSI/AHAM AC-1-2015, Clean Air Delivery Rate (CADR) is a measure of the appliance's ability to reduce aerosol particles in the size range from 0.1 to 11 μm . The standard methods provide a means to compare and evaluate different brands and models of household portable air cleaners regarding characteristics significant to product use. This study aimed to investigate the performance of the personal/portable air cleaners.

An aerosol nebulizer was used generate submicron DEHS particle (CMD 205 nm, GSD=1.93). A condensation particle counter was used to monitor aerosol number concentration at high sampling rate of 1 Hz. A scanning mobility particle sizer, SMPS, was used to measure the aerosol concentrations and size distributions upstream and downstream of the air cleaners, to obtain the filtration efficiency as function of particle size, and the most penetrating particle size (MPPS). The CADR values were determined using a standard chamber as required in AC-1-2015, and a smaller chamber, with volume of 59 cm x 49 cm x 49 cm = 114 liter. A variety of air cleaners of different sizes, from personal to portable, were tested for CADR. Combinations of filter layers and blower types were tested for searching the optimal CADR.

All commercially available air cleaners tested in this work claimed using High-Efficiency Particulate Air, HEPA filter, but none of them met the definition of HEPA, even when operated under the lowest flow rate. The most penetrating sizes of most of the air cleaners fell in the range of 0.2 – 0.4 μm , a typical indicator of mechanical filter. The performance of air cleaners is influenced by filtration efficiency of filter, pressure drop across filter, and fan performance characteristics. There exists a highest CARD, that is the best combination of filtration efficiency and pressure drop for a fixed energy consumption. Most of the portable indoor air cleaners apparently are powerful enough to create a complete mixing environment inside the standard test chamber during CADR measurements, based on the linear decay

trend. However, for the personal air cleaners, a smaller test chamber might be more appropriate to obtain a correct CADR value. The CADR increased with increasing flow rate of indoor air cleaner, probably due to increased mixing, coagulation and wall deposition. However, from the power consumption perspective, the CADR/watt factor might not increase with increasing flow, but depended on the characteristic fan performance of the blower.

Development of Composite Filters with High Efficiency, Low Pressure Drop, and High Holding Capacity PM2.5 Filtration

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Chi-Yu Tien, National Chiaotung University

Chien-Yuan Peng, Virginia Commonwealth University

Abstract:

Many efforts are being made to develop filters with high efficiency and high holding capacity but remaining a low pressure drop. A two-layer composite filter to achieve the goal was developed, in which the first layer was a charged coarse fibers to provide large void space for particle loading and the second was a thin layer of charged melt-blown with finer fibers to enhance the overall efficiency. Experimental results showed that although the new composite media had a lower initial efficiency than the other two HEPA filters (PTFE and glass fiber filter), its figure of merit (FOM) was the highest. Besides, the composite media had a better holding capacity for PM2.5 than the other two. At a fixed mass load, i.e., 2 g m^{-2} , the PTFE ($\Delta P=380 \text{ Pa}$) and glass fiber ($\Delta P=165 \text{ Pa}$) required around 7.6 and 3.3 times more power, respectively, than the composite media ($\Delta P=50 \text{ Pa}$). Due to the low charge level of the coarse fiber layer and the fine fiber diameter of the melt-blown layer, resulted in no efficiency reduction along the loading process. Theoretical analysis showed that the charge shielding and the loss of efficiency in the successive top-down layers were timely compensated by the efficiency increase caused by the loading effects, which made the composite media a much uniform deposition of PM2.5 in layers. This was the main reason resulting in the high holding capacity and low pressure drop of the current composite media which acted like a perfect depth filtration media.

PM combustion enhancement effect and reaction mechanism by potassium in continuous regeneration type PM removal device

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Kyushu University

Kento Yokoo, PM combustion enhancement effect and reaction mechanism by potassium in continuous regeneration type PM removal device

Hedeki Matsune, PM combustion enhancement effect and reaction mechanism by potassium in continuous regeneration type PM removal device

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Abstract:

Particulate matter (PM) is microscopic liquid or solid matter suspended in the atmosphere and originates from either man-made or natural sources. A large fraction of PM is associated with the combustion of fossil fuels, such as coal, oil, gasoline and wood, in vehicles, electric power plants and various industrial processes. The particle diameter of PM emitted from various combustors decreases with the progress of combustion technology. PM is an environmental pollutant and adversely affects human health. In particular, fine PM (PM_{2.5} - particle matter with aerodynamic diameters less than 2.5 μm) tends to penetrate into the bronchial tubes and enter deep into the lungs. PM_{2.5} is identified as a causative agent of respiratory disease, circulatory disease and lung cancer. Millions of people prematurely die every year due to PM_{2.5} over the world. Exhaust aftertreatment devices, such as bag filters, electrostatic precipitators and Diesel Particulate Filters (DPFs), are currently used to collect PM emitted from various combustors. However, recent modeling and experiments indicated that PM_{2.5} can potentially penetrate through these devices. Therefore, we have developed a fluidized bed type PM removal device that takes advantage of adhesion forces, such as the van der Waals forces, electrostatic forces and liquid bridge forces, to remove PM_{2.5}. It was shown that this device is highly efficient for collection of PM_{2.5}. Furthermore, fluidized beds are well-known low-temperature combustors, possessing the potential to decrease the operating temperature in continuous regeneration mode. This device could be operated at bed temperature of 400 °C, although existing continuous regeneration devices require temperature of 650 °C for PM combustion. The objective of the present study is to further decrease the operating temperature in continuous regeneration mode. In the area of coal science, mineral contained in coal is known as a combustion promoter. It was reported that when carbon was burned in abutting contact with mineral, reaction temperature of carbon decreased about 150 °C. Mineral has been applied to continuous regeneration PM_{2.5} removal device. An experimental study has been performed to investigate the effect of combustion enhancement by means of bed

particle with and without potassium catalysis. As a result, PM collection efficiency increases when potassium is added to bed particle, because PM combustion is enhanced and the surface of bed particle is kept clean. In addition, this device can be operated under bed temperature of approximately 350 °C in continuous regeneration mode by the enhancement of PM combustion. Furthermore, the X-Ray diffraction (XRD) patterns of bed particle were collected to clarify the reaction mechanism on promotion of PM combustion. Potassium was supported on bed particles as potassium carbonate, and potassium carbonate was detected to about same extent even after the experiment. It is shown that potassium is hardly lost during experiment and has a combustion promoting effect as a catalyst.

White light photocatalytic air filter with high antimicrobial performance against bioaerosol

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Abstract:

Indoor air quality (IAQ) has strong relation with human health because people spend most of their lifetime in indoors. Air filtration systems are widely used for improving IAQ, however, they may be a source of contamination from hazardous microorganisms which threaten the human health. In the HVAC or air purifier system, airborne microorganisms such as bacteria, fungi, and viruses, can be captured on the filters with preserving their viability, and some even can grow due to nutrients in the dust under the proper environmental condition. Additionally, such microorganisms can generate rank odor and cause various diseases such as allergic rhinitis, asthma, and chronic obstructive pulmonary diseases. Therefore, the development of the air filtration system which can prevent the growth of microorganisms on filters is required for a long time.

Over several decades, the antimicrobial air filtration technologies have been widely investigated because they can be simply applied to conventional air-conditioning systems. Many studies showed that air filtration technologies used photocatalytic inorganic nanoparticles are effective in controlling airborne microorganisms. Particularly, the air filter using photosensitive semiconductors, such as titanium dioxide, that absorb ultraviolet (UV) light to generate hydroxyl radicals ($\text{OH}\bullet$) is considered promising of proactive antimicrobial material. Because hydroxyl radicals and other reactive oxygen species induced by the light source with ambient oxygen and water vapor, are effective elements to denature the cell membrane and cell wall of microorganisms. However, UV light comprises only a small proportion of the total radiation in sunlight and requires additional equipment for real-world application. To resolve this problem, many studies were performed to enhance visual light photocatalytic utilization of titanium dioxide.

In this study, we fabricated the antimicrobial air filter through synthesizing of new materials of titanium dioxide and crystal violet (CV) which resolved limitation of light photocatalytic problem as mentioned above. CV is a commonly used component of household paint and the visual light-activated antimicrobial agents. The antimicrobial air filter was fabricated by the simple aerosol-deposition method using the photobactericidal solution which was produced with a single step and short-term synthesizing of titanium dioxide and CV.

The antimicrobial filters were assessed in terms of the pressure drop, filtration efficiency, and antimicrobial activity. The *Staphylococcus epidermidis* bioaerosol was used as test microorganism. Antimicrobial activity test is performed under various visual light exposure time. In result, the average filtration efficiency was the high rate of ~98% and no statistically significant differences in filtration performance between samples as a function of the photobactericidal solution deposition time. In the antimicrobial activity test, the 2 hours visual light exposed solution-deposited filter showed the highest antimicrobial activity of ~99%. This study provides valuable information for the development of bioaerosol control systems that are environmentally friendly and acceptable for use in indoor environments.

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Effects of particle loading on the filtration efficiency and pressure drop growth of composite electret media for HVAC systems

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Abstract:

The electret filter media are widely used in HVAC systems to ensure good indoor air quality with low energy consumption. However, the reduction of filtration efficiency and the shortening of lifetime with increasing particle loading remain to be the persistent problems. To solve these problems, three types of composite filter media (CM1, CM2 and CM3) were designed and tested, which were comprised of 2-3 different types of electret (charged) media with a total thickness of <1 mm, including a coarse fiber (CF), a commercialized MERV13 (MERV13), a homemade melt-blown (MB) and a homemade bead-on-string (BS) layer. The individual electret medium were tested first and results showed that the reduction of filtration efficiency was found to closely relate to the particle holding capacity, media porosity and fiber diameter. The composite filter media were designed according to the results from the tests for individual layers. It was found the CM2 (CF+CF+BS) and CM3 (CF+MERV13+BS) not only had high initial efficiency (>90 % at MPPS under 0.1 m/s), low initial pressure drop (29.4 and 41.3 Pa) but also high loading capacity, and no efficiency reduction. The study concludes that an optimum composite electret filter media should be comprised of different layers of filter media with high to low holding capacity, and low to high filtration efficiency in the flow direction. Such composite filter media has a great potential to offer a longer service lifetime with the additional advantage of energy saving.

Keywords: electret filter media; composite filter media; filtration efficiency; holding capacity; efficiency reduction; HVAC

Development of a Hybrid Electrostatic Precipitator - Filtration System

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Abstract:

Both ESPs (Electrostatic precipitators) and baghouses with electret filters are control devices used to control the source pollutants effectively, which can be used in restaurants, semiconductor processes and petrochemical industries. However, the electret filter in the baghouse is normally clogged by the particle accumulation causing the rapid decrease in its collection efficiency. Installing the ESP in front of the filter can prevent the clogging problem. In this study, a novel Hybrid Electret Filtration System (HEFS), which consists of the ESP and the electret filter, was developed for removing the sticky particles effectively without the clogging problem. The ESP, which consists of needle-type electrodes and a stainless steel mesh as a grounded electrode, is used to charge and collect a part of particles. The electret filter, which is composed of permanently charged electret fibers, can enhance the particle collection efficiency due to strong electrostatic attractive forces. The results show that, in comparison to the theoretical and experimental results of IPA treated high eff. filter and clean high eff. filter, the collection efficiency of clean high eff. filter is apparently higher than IPA-treated high eff. filter, and this result was caused by the dielectrophoretic force in uncharged particles and the Coulombic force in charged particles. In initially clean conditions, the collection efficiencies of the medium-efficiency and high-efficiency electret filters at the flow rate of 30 m³/min are 72.9% and 90.6%, respectively. However, under loading conditions, the collection efficiencies are reduced to 18.6% with the particle deposit of 8.2 g/m² and 40.0% with the particle deposit of 7.3 g/m², respectively. In comparison, the HEFSs with the medium-efficiency and the high-efficiency filters show much better collection efficiencies. In initially clean conditions, the collection efficiency the HEFS is 89.5% for the medium-efficiency and 99.9% for the high-efficiency filters, respectively. Under loading conditions, the collection efficiency of the HEFS is 48.5% with the particle deposit of 8.2 g/m² for the medium-efficiency electret filter and 72.8% with the particle deposit of 7.3 g/m² for the high-efficiency electret filter. Therefore, the HEFS can be used for removing the sticky particles with a high collection efficiency under the high loading conditions.

Keywords: ESP, electret filter, catering control device, HEFS

The Application of Nitrogen-Doped Carbon Quantum Dots and Zinc Hydroxide Stannate/SnO₂ Binary Complexes on Nitrogen Oxides Removal

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Abstract:

Nitrogen oxides (NO_x) are emitted from the combustion process of stationary pollution sources (such as power plants, incinerators, etc.) and mobile pollution sources (such as steam locomotive). The cigarettes, gas stoves, kerosene heaters, wood burning, are also NO_x pollution sources. NO_x will react with sunlight and other chemicals to form smog. It will cause irritation of the respiratory system, eyes, and skin, aggravation of respiratory diseases, particularly asthma, and coughing and choking. In this study, N-CQDs were prepared by simple and low-cost hydrothermal method with citric acid and urea as carbon sources, and then N-CQDs/ZnSn(OH)₆/SnO₂ was successfully synthesized by using the solvothermal method with SnCl₄·5H₂O and C₄H₁₀O₆Zn as metal sources.

The results showed that the pH of the ZnSn(OH)₆ precursor affects whether the product contains SnO₂, and in the 400 ppb NO photocatalytic degradation experiment, the presence or absence of SnO₂ is observed in the visible light of ZnSn(OH)₆. 36.6% of NO_x removal for N-CQDs/ZnSn(OH)₆/SnO₂ is higher than 16.8% for N-CQDs/ZnSn(OH)₆. N-CQDs/ZnSn(OH)₆/SnO₂-600 has the best removal efficiency under visible light, achieving 149 ppb of NO_x removal. Additionally, the production of nitrogen dioxide was almost 0 ppb. Furthermore, the catalytic process does not produce secondary contaminants - nitrogen dioxide. It is an environmentally friendly material. The introduction of N-CQDs enables the photocatalyst working under visible light and it is not easily deactivated during the reaction process. The synergistic effect of SnO₂ and ZnSn(OH)₆ made the best catalytic activity of N-CQDs/ZnSn(OH)₆/SnO₂ composite.

Non-uniform Filtration Velocity of Process Gas Passing through a Long Bag Filter

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Abstract:

Filtration velocity affects significantly pressure drop through a bag filter. We conducted numerical simulations regarding flow characteristics along a bag filter in detail. We newly found that the filtration velocity becomes more non-uniform along the axial direction of a long bag filter as the height of the filter becomes larger.

3-D numerical analysis of EHD turbulent flow and particle transport in a spike-honeycomb electrostatic precipitator

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Abstract:

Keywords: electrostatic precipitator; fine particle; simulation; ionic wind; vortex

Particulate matter (PM) in the air is a well-recognized carcinogen for humans and has caused global concerns over the past few years. Electrostatic precipitators (ESP) have been proven to be a promising technology for the removal of fine particles from flue gas. Numerous numerical studies have been carried out to achieve a better understanding of all important phenomena in ESPs during the last several decades. However, these work mainly analyzed the corona discharge with wire electrodes or under two-dimensional coordinates. The interactions among corona discharge, flow field, particle precipitation are still not clearly understood, especially in terms of spike-honeycomb electrostatic precipitators, which are widely used in practical applications.

In this study, a comprehensive 3D Computational Fluid Dynamics model was established to investigate the coupled processes among corona discharge, gas flow, particle charging and transport in the spike-honeycomb ESP. Each sub-process is separately described by the relevant governing equations and these processes interacted with each other. Moreover, the corona-onset electric field strength at each position on the discharge electrode surface was respectively set to improve accuracy.

Results indicated that the electric field and ion charge density around the needle tips were highest, which played a key role in corona-electrostatic field and accompanied by the generation of ionic wind. The maximum velocity of ionic wind could reach 13.81, 11.74 and 9.42 m/s under the applied voltage of 27, 21 and 15 kV. The flow field was strongly disturbed by generated high velocity ionic wind from the needle tips, and the flow field could be divided into three regions (ionic wind affected region, vortex and back flow region) according to the direction of gas flow velocity. Meanwhile, the inhomogeneous distribution of the deposited particle has occurred. On one hand, ionic wind enhanced the aggregation of particles in the upstream, on the other hand, the deposited particles significantly reduced in the downstream. Optimizing the electrode configuration according to the inhomogeneous distribution of the flow field, and rationally using the vortices generated by ionic wind is meaning and energy-efficient.

This simulation data gives a fundamental in optimizing the ESP design and efficiently removing fine particles from flue gas.

A numerical investigation of effect of dust layer on particle migration in low temperature electrostatic precipitator

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Abstract:

Electrostatic precipitation processes have been widely applied to remove particulate matter from flue gases in coal-fired power stations. A high negative voltage is usually applied to a discharge electrode so that the gases are ionized in such processes. When the suspended particles in flue gases enter the ionized space, they are electrically charged and deposited on collection plates to form layer of particle packing. However, the dust layer is generally exist during charged particles precipitated on collection plate. The negative effect of precipitated dust layer on the collection plate will deteriorate the collection efficiency of electrostatic precipitator (ESP) seriously due to some important factors, such as dust resistivity, thickness of the accumulated dust and so on. In this research, a simulation method by computational fluid dynamics (CFD) method was applied to study the particle collection performance of ESP system with and without dust layer. Also the detailed electric parameters and particle capture performance in the two dimensional wire-plate electrode configuration were simulated. The results show that the voltage current characteristics and detailed distribution of electric field and ion charge density are totally different under different dust resistivity conditions. And the effect of dust layer is significant and causes collection efficiency sharply decreased with increasing thickness (1 to 5mm) of dust layer. Meanwhile, some parametric studies were present to improve the ESP performance with dust layer.

Keywords: Dust layer, CFD, collection efficiency, dust resistivity.

Insights into the role of the dust layer on discharge over a wide range of temperature

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Abstract:

Keywords: electrostatic precipitator; resistivity; temperature; electric field intensity

Particles with aerodynamic diameter less than 10 μ m have serious impacts on the environment and health. Electrostatic precipitator is typically used to remove particles for its high efficiency and wide adaptability. Particles are deposited on the collecting plates due to electrical force. However, dust layer will affect the discharge parameters under different temperature conditions. The charge emitted by the discharge electrode accumulates on the dust layer and causes an increase of the magnitude of electric field within this layer, decreasing the magnitude of electric field between wire and dust layer, which reduce the collection efficiency of ESP.

In this study, the experimental system setup for wire–plate discharge was designed to obtain the discharge characteristics with dust layer deposited at collection plates. The effects of temperature, wire–plate distance, thickness of the dust layer, dust resistivity and other particle properties on the discharge characteristics were investigated and critical voltage for mutation of space discharge characteristics was obtained. The results demonstrated that the discharge current would increase rapidly when the voltage between wire and plate was higher than critical voltage, which could cause the generation of the back discharge, and the voltage between the wire and dust layer decreased. Critical voltage decreased with the increase of the dust layer thickness and decline of the wire–plate distance, also the inhibition of dust layer on space discharge was enhanced. Simultaneously, critical voltage was inversely proportional to dust resistivity. High dust resistivity increased the electric field intensity of dust layer, and dust layer was more likely to be broken down, deteriorating the space discharge characteristics. In addition, the ionization coefficient of air reduced under the higher temperature conditions, decreasing the breakdown voltage of air and causing the increase of discharge current and the electric field intensity of dust layer with the same applied voltage, which reduced the electric field intensity between the wire and dust layer. Meanwhile, some studies were present to obtain theoretical criterion for dust layer properties and critical voltage. This research gives a fundamental in enhancing the ESP performance with dust layer.

Synthesis of SrFexTi1-xO3- δ nanocubes with tunable oxygen vacancies for selective and efficient photocatalytic NO oxidation

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Abstract:

Nitric oxides (NO_x) are one of the primary gaseous pollutants in air that lead to the occurrence of haze and O₃. With the continuous increase of automobiles and burning sources in cities, the control of NO_x emission still exist as a critical issue which needs to be solved. Photocatalysis is a green technology that can remove low concentration NO_x from air, while the key issue lies in the synthesis of durable and highly selective photocatalysts. Crystal defects of metal oxide semiconductors play critical roles in tuning activity and selectivity in photocatalysis mediated NO reactions. Herein, we provide detailed insight into the relationship between oxygen vacancy manipulation by extrinsic Fe³⁺ substitution in SrTiO₃ host lattice and the photocatalytic performance of NO abatement. In particular, the hydrothermal synthesized SrFexTi1-xO3- δ nanocubes (denoted as SFTO-hyd sample) rather than the impregnated-post annealing sample, enabled oxygen vacancy formation, and promoted O₂ adsorption and superoxide anion radicals formation. The SFTO-hyd (x=5%) sample showed remarkably higher NO removal activity and selectivity under Xe lamp ($\lambda > 420$ nm), in comparison with the pristine SrTiO₃, commercial Degussa P25 and impregnation-doped SFTO sample, underlining the important roles played by coexisted Fe³⁺ sites and oxygen vacancies. The in situ diffuse reflectance IR spectroscopy (DRIFTS) mechanically revealed that SrTiO₃ provided Lewis acidic sites for NO dark adsorption and photoreaction with nitrates as final products; the substitutional Fe³⁺ sites provided more active sites for NO adsorption and photoreaction with enhanced number of radicals. This study deepens the understanding of photocatalytic NO abatement on defective surface, and may also provide a simple and cost effective strategy for synthesizing efficient and selective photocatalysts for environmental remediation.

Calibration of particle number concentration measured by mobility-based particle size distribution instruments with uncertainty evaluation

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Abstract:

Particle size distribution (PSD) measurements based on electrical mobility classification can accurately measure particle size and number concentration of fine particles and are used for various applications. Performance evaluation methods for them, however, have not been established, especially for particle number concentration. For conventional scanning mobility particle sizer (SMPS) spectrometers that consist of separable components accessible to the user, the performance can be evaluated to some extent by individually inspecting and/or calibrating the components such as the charger, classifier, and detector. On the other hand, the fast-response instruments such as TSI's fast mobility particle sizer (FMPS) are packaged so that the integrated components are not separable for individual testing. The same can be said for recent compact, battery-powered portable instruments. For those instruments, techniques to evaluate the overall performance of a complete system as a whole are needed by treating each instrument as a "black box". Such techniques would be also useful for testing conventional SMPS's in addition to the tests/calibrations of individual components. Such techniques would also allow evaluation of the performance of a charger in a conventional SMPS in terms of the extrinsic charging probability.

We propose a method that evaluates the overall performance of a particle size distribution measurement based on checking the accuracy of the total number concentration using monodisperse particles such as polystyrene latex (PSL). In this method, the total number concentration of monodisperse particles of the same aerosol is measured in parallel by a test PSD instrument (e.g., SMPS) and a reference CPC. The total number concentration that is determined by integrating the size distribution density function measured by the test PSD instrument is compared with the number concentration measured by the reference CPC. Monodisperse particles are generated by passing particles from an aerosol generator (e.g., electrospray) through a neutralizer and subsequently classifying them with a differential mobility analyzer (DMA). Then, after mixed well with a dilution air, particles are delivered to the test PSD instrument and reference CPC simultaneously. By using a reference CPC that has been calibrated with traceability to a national or international standard (e.g., AIST's primary standard), the test PSD instrument calibrated by this method will have metrological traceability to the standards with respect to particle number concentration.

We applied this method to a commercial instrument, which was a TSI SMPS model 3938L75. Monodisperse PSL particles of 4 sizes (particle diameter: 30, 60, 100, and 200 nm) were used, and the total number concentration measured by the test PSD instruments was compared to the value by calibrated CPCs. In this evaluation, it was found that our SMPS showed good performance and had small particle size dependence. We will report the results and the uncertainty of this evaluation.

Aerosol Deposition in the Sampling Train of Extractive PM CEMS

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Abstract:

There are several PM CEMS currently commercially available. These instruments should follow the Performance Specification 11 to establish the initial installation and performance procedures that are required for evaluating the acceptability of a PM CEMS. However, the performance of PM CEMS might be plagued with aerosol deposition in the sampling train, from the standpoint of aerosol sampling. The aims of this study are to evaluate the particle deposition in the sampling train and to improve the sampling train.

For aerosol penetration test, an ultrasonic atomizer was used to generate micro-meter-sized challenging NaCl particles. The aerosol output was then introduced into the test chamber through a radioactive source, 10 mCi Am-241, to neutralize aerosols to the Boltzmann charge equilibrium, before diluted with filtered dried air. An Aerodynamic Particle Sizer was employed to measure the aerosol size distributions and number concentrations upstream and downstream of the sampling probe. The sampling train was divided into three parts: sampling inlet with an elbow or goose-neck, connecting straight tube, and elbow adaptor connecting to TEOM or beta-gauge. The experimental data were then compared with the empirical models.

The loss of particle loss in the typical sampling train was found to be significant. The elbow or goose neck design resulted in over 10% aerosol deposition for 10- μm particles. The 192 mm long straight tube also caused over 10% deposition loss. The connecting elbow adaptor caused 20% deposition loss because of higher velocity. The overall loss of 10- μm particles was up to 40%, while the 2.5-micrometer particles experienced 5% loss. The experimental data showed higher aerosol deposition loss than the modelled ones. The discrepancy between the experiment and model was mainly on the inertial impaction loss in the elbow. That means the effect of curvature-diameter ratio of the elbow on the deposition loss needs to be further investigated. Other factors such as elastic properties of the particle and the elbow tube, the roughness might also contribute to the bounce-off and make the deposition loss unstable and unpredictable.

The currently commercially available PM CEMS sampling trains were designed to follow the isokinetic protocol, but did not consider the aerosol deposition loss in the sampling train due to gravitational

settling and inertial impaction. The aerosol size separator with cut-point of 1.0 micrometer is highly recommended because of deposition loss due to gravitational settling and inertial impaction is less than 1%. The deposition loss is less than 5% if the 2.5 μm pre-separator is used. If the pre-separator is adopted for 1.0 or 2.5 μm , the isokinetic sampling criteria might become not that critical.

Proposed Conventions for PM Size-selective Sampling

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Abstract:

Size selective aerosol samples were acquired due to the application of information on how the aerodynamic size of aerosols determines the inhalability and the regional deposition of particles within the respiratory tract. Although various forms of particle size selective sampling criteria have been recommended, there has not been any consistent rational approach to defining the size fractions of interest. In this study, not only the current state of the science on particle size selective sampling was presented, but also explored what new sampling criteria and instruments may be on the horizon.

In 1989, Sidney Soderholm developed a definite numerical model that comprehensively explains these three size-selective sampling conventions. On the environmental side, USEPA promulgated the PM₁₀ and PM_{2.5} standards in 1987 and 1997, respectively. In 40 CFR part 53, the sampling effectiveness (expressed as a percentage) and the test procedure were described. Yet, only penetration data points were issued to define these two sampling conventions. No mathematical model is officially developed to define these criteria. In addition, a minor defect of PM sampling conventions is that the PM_{2.5} penetration rate is higher than PM₁₀, as the aerosol size is smaller than 2 μm , indicating lack of communication when developing these two sampling conventions. Therefore, the present study used the Soderholm's formula to simulate PM₁₀ and PM_{2.5}, and to correct the mismatch, so that the PM_{2.5} is part of PM₁₀, for the whole aerosol size range of concern.

This study involves two parts: theoretical discussion and experimental operation. The original occupational formula $SI(d)=0.5(1+e^{-0.06d})$, proposed by Soderholm, is employed as the starting formula for the separation of diameters to reasonable and feasible PM₁₀, PM_{2.5}, PM_{1.0}, PM_{0.1} and PM_{0.04} split curve modes. An ultrasonic atomizer was used to generate micro-meter-sized PST (potassium sodium tartrate tetrahydrate) particles as solid challenge aerosols. A syringe pump delivered the PST solution to the ultrasonic atomizer to generate challenge particle. The submicron challenge aerosols were produced using a constant output aerosol generator.

The present study proposes a series numerical model for PM size-selective samplers, covering the cut point from 10 μm (PM₁₀) to 40 nm (PM_{0.04}). The two main coefficients (Γ , Σ) outline the 50% cut off size and the slope of the separation curves. The Γ and Σ of PM₁₀, PM_{2.5}, PM_{1.0}, PM_{0.1}, PM_{0.04} were (11.245, 1.277), (2.535, 1.120), (1.005, 1.090), (0.100, 1.225), (0.040, 2.45), respectively. The virtual

cyclone is recommended to replace the conventional cyclone samplers to avoid the aerosol loading effect. However, the slope of the virtual cyclones is less sharp.

Evaluation and improvement of condensable particulate matter measurement method

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Abstract:

The PM_{2.5} has been reported in many studies more harmful on human health than TSP. The primary PM_{2.5} emitted from stacks can be classified as 'Filterable (FPM)' and 'Condensable (CPM)'. Based on Taiwan EPA reports, the CPM concentration is higher than FPM by more than a factor of two. However, the CPM measuring method is known to be plagued by many factors. The aim of this work was to evaluate the factors affecting CPM measurement and to improve the accuracy of the CPM method.

The test procedure mainly followed USEPA Method 202. The 100 ppm SO₂ was used to evaluate the positive bias, and the 99.999% N₂ was used to perform the purging. The SO₂ meter was employed to measure the SO₂ concentration at the downstream of the impinger. The amount of breakthrough of SO₂ could be used to calculate the amount of SO₂ still resided in the water after nitrogen purging. The Glycerol and DEHS particles were generated by the Collision Atomizer and were regarded as organic CPM. The deionized water, acetone and hexane were used to rinse and recover the CPM deposited in the sampling apparatus. The sample recovery efficiency was then compared with the reference filter. A condensation particle counter, P-trak, was used to measure the CPM filter holder leakage. The AM-241 was used to remove static charge on the beaker when placed in the weighing chamber.

The results showed the positive bias caused by SO₂ increased with increasing waiting time (from stop sampling to start purging), water volume, and oxygen concentration, and decreased with increasing purging time. After 1-hour purging, there are still 60% residual of SO₂ in the water. The N₂ purging also evaporate the Glycerol particle collected on the CPM filter and result in the underestimation of CPM mass. The CPM recovered efficiency was about 90% by 260 ml of DI water, 125 ml of acetone and 360 ml of hexane. The efficiency could reach 99% by double the reagent volume. The leakage of CPM filter holder was about 4%, because the filter did not totally cover the holder rim. This could be improved by adding an O-ring between the filter and the holder. The leakage could drop to 0.06% when the O-ring was used. The procedure of sample transferring was found to cause a significant loss of CPM mass. The loss decreased when increasing the transferring volume. The static electricity of the beaker caused

overestimation of the CPM mass. In conclusion, the positive bias was mainly caused by SO₂ and the negative bias was caused by N₂ purging, filter holder leakage, incomplete sample recovery and sample transfer. To avoid or reduce these biases, the purging should be done soon after sampling, and a new CPM filter should be used prior to nitrogen purging. The static electricity of the beaker should be removed before weighing.

Measurements of particulate matter mass concentration using quartz crystal microbalance and electrostatic particle concentrator

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Abstract:

Respirable particulate matter (e.g, PM_{2.5} and PM₁₀) is one of the most critical global pollutants, causing adverse effects on human health, and various instruments to measure its mass or number concentration have been developed. Of these, quartz crystal microbalance (QCM) based instruments have received much attention owing to high sensitivity, rapid response, low cost as well as portability for on-site measurements. However, there are still significant drawbacks: bounce due to poor adhesion in the inertial impaction based instruments, need for frequent cleanings of the crystal electrodes, and non-uniform distribution of collected particles, especially in the piezoelectric electrostatic precipitators, which still requires further improvement. In this study, an instrument capable of measuring the mass concentration of particulate matter and of avoiding the drawbacks of previous instruments is proposed. The instrument consists of two major components: an electrostatic particle concentrator (EPC) and a QCM. Airborne red fluorescent polymer microspheres, a representative of PM, were generated using a three-jet Collision nebulizer. A 5MHz QCM crystal was fixed inside the EPC, and the crystal electrode working as a collection electrode was wired to a voltage of -10kV, under which charged particles were attached onto the quartz crystal electrode by electrostatic force at Q = 1.2 L/min for 20 minutes. This was followed by the recording of QCM frequency change for further calculations. The experimental results showed that the resonant frequency shift of the crystal turned downward linearly ($R^2 = 0.9997$) with the PM mass loading. Moreover, the frequency response for 30 minutes reveals no particle bouncing. Fluorescent images showed very uniform distribution of captured particles on the quartz crystal electrode. This instrument can be further improved by using higher resonance frequency QCM crystal so as to improve mass concentration sensitivity.

An optimized calibration method for nephelometer: a case study in winter Shanghai

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Abstract:

Integrating nephelometer, as an instrument for measuring the scattering coefficient of aerosol particles, is adopted to monitor and study optical propriety. Instrument results needs correction in order to ensure the accuracy and reliability. In this work, the calculated correction factor at three wavelengths ($\lambda=450\text{nm}$, 525nm , 635nm) was given to reduce and quantify the uncertainties for aerosol optical properties measured with Aurora 3000 integrating nephelometer.

Based on particles size distribution, measured scattering coefficient and absorption coefficient to obtain the variation range of atmosphere aerosol complex refractive index ($m=n+ki$) by means of a optimization inversion method. The correction factor for integrating nephelometer is obtained by intercomparasion of calculated and measured scattering coefficient. In addition, Ångstrom exponent (Å) and single scattering albedo (ω) can be accurate determined.

Numerical study of aerosol sampling inlet design for unmanned aerial vehicles

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Abstract:

Traditionally, atmospheric measurement has been associated with ground station or manned aircraft with a set of bulky airborne sensors. However, spatial and temporal resolution of data from ground or manned aircraft is relatively low and often inadequate for local areas. In the last decade, increasing improvements in unmanned aerial vehicles (UAVs), together with development of miniaturized measuring technologies, provide excellent opportunities for atmospheric measurements. UAV can offer high versatility and flexibility, as compared to manned aircraft or ground station, and can operate rapidly without planned scheduling. Additionally, they can fly at low altitudes and slowly, with the ability of acquiring spatial and temporal high resolution data, representing important advantages against conventional measuring methods. However, UAV usually flies at various speed, which could lead to a non-isokinetic sampling condition (non-equivalence velocity between the sampling inlet and circumambient flow) for aerosol and result in biased measurements. Hence, there is a special need to design and evaluate a sampling inlet for UAV measurements of atmospheric aerosols. In addition, the other environmental conditions, which will possibly affect the measurement, including the flight altitude, wind direction and the boundary layer of flying UAVs, have to be evaluated as well. In this study, the flow field of the flying UAV and the particle trajectories of the sampling inlet were analyzed by a numerical simulation. Based on the numerical results, we propose a guidelines of sampling inlet setting on UAV to mitigate the interferences. Additionally, a set of curves, which could correct the overestimation of particle concentrations, was developed for post-correction.

Surface-discharge microplasma aerosol charger (SMAC) operated at high flow rate

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Abstract:

Electrical charging of aerosol is an important pretreatment for electrically manipulating (classify, detect, collect, etc.) aerosol particles. Unipolar charger is an effective tool to obtain high charging efficiency, particularly against nanoparticles (<100nm). However, it has drawbacks that the particles are multiply charged and the charged particles are easily captured in the charging device. We have developed high throughput and high efficiency charger using the surface-discharge microplasma device (SMAC, Kwon et al., 2007, Manirakiza et al., 2013). In the present study, the applicability of the unipolar SMAC to the high flow rate (10 to 30L/min) charging of the nanoparticles was investigated. Monodispersed and electrically neutralized Ag nanoparticles (3 to 10nm) and NaCl nanoparticles (15 to 200nm) were prepared by evaporation condensation, neutralization (by 241-Am), size classification (by the Differential Mobility Analyzer; DMA), re-neutralization (by another 241-Am) and collection of charged particles (by the electrostatic precipitator). Intrinsic charging efficiency was over 90% for the particles larger than 100nm, and 50 to 80% for 10-nm particles, respectively. Size-dependency of the intrinsic efficiency was well represented by the diffusion charging model with the fixed ion concentration. In addition, extrinsic efficiency (throughput of the charged particles) of 80% for 100nm and 50% for 50nm particles were also obtained, respectively. The effect of multiple charging is also evaluated by a tandem DMA method.

Investigation of solid-, liquid-, and gas-phase nitrophenols by Raman Spectroscopy

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Abstract:

Nitrophenols are an important class of carcinogenic and phytotoxic pollutants that have been the subject of environmental scrutiny since the 1970s. Anthropogenic emission are main sources of nitrophenols into the troposphere, such as vehicle emission and biomass combustion. Nitrated phenols, with at least one nitro and one hydroxyl group attached on the benzene ring, have effects on the environment and on living beings that cannot be ignored. Due to their strong absorption in the near-ultraviolet and visible regions, nitrated phenols are classified as poorly optical characterized. Therefore, the high-precision measurement of nitrophenols rises significant concern. Traditional measurement methods of nitrophenols mainly include gas chromatographic method and chemical ionization mass spectrometry. In the work, three isomers of nitrophenol (2-Nitrophenol, 3-Nitrophenol, 4-Nitrophenol) in solid-, liquid- and gas-phase were investigated based on Raman spectroscopy. Firstly, the solid-state nitrophenol isomers were measured by a self-constructed Raman spectrometer at 785 nm. The laser beam was focused on the solid substances in the cuvette after passing through lens and bandwidth filter. The scattered light at angle of 90 degree with the incident light was filtered by lens (Aspheric Lenses and Planoconvex Lens) and edge filters, and then received by the spectrometer and CCD detector. Raman spectra of these three isomers of nitrophenol in solid state were obtained. The solid nitrophenol isomers were further mixed with deionized water, and aqueous solutions of nitrophenol isomers were obtained. The Raman spectra of the aqueous solutions and the mixture of aqueous solutions and self-synthesized silver nanoparticles were then obtained using the self-constructed Raman spectrometer, respectively. The difference between their Raman signals was discussed. Meanwhile, the isomers of nitrophenol were heated to volatilize, and the Raman spectra of gas-phase nitrophenols was measured. Furthermore, Raman spectra of three nitrophenol isomers in solid-, liquid- and gas-phase were measured or not. The abovementioned work will provide effective support for the investigation of gas condensation process of nitrophenols.

Evaluation method for testing accuracy of particle number concentration by Engine Exhaust Particle Sizer (EEPS)

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Abstract:

Particle size distribution (PSD) measurements based on electrical mobility classification can accurately measure particle size and number concentration of fine particles and are used for various applications. Performance evaluation methods for them, however, have not been established, especially for particle number concentration. For conventional scanning mobility particle sizer (SMPS) spectrometers that consist of separable components accessible to the user, the performance can be evaluated to some extent by individually inspecting and/or calibrating the components such as the charger, classifier, and detector. On the other hand, the fast-response instruments such as TSI's fast mobility particle sizer (FMPS) are packaged so that the integrated components are not separable for individual testing. The same can be said for recent compact, battery-powered portable instruments. For those instruments, techniques to evaluate the overall performance of a complete system as a whole are needed by treating each instrument as a "black box".

We evaluated the overall performance of a TSI's Engine Exhaust Particle Sizer (EEPS) model 3090 based on checking the accuracy of the total number concentration using monodisperse particles such as polystyrene latex (PSL). The EEPS is a kind of fast-response instruments. In this evaluation, the total number concentration of monodisperse particles of the same aerosol is measured in parallel by a test EEPS and a reference CPC. The total number concentration that is determined by integrating the size distribution density function measured by the test EEPS is compared with the number concentration measured by the reference CPC. Monodisperse particles are generated by passing particles from an aerosol generator (e.g., electrospray) through a neutralizer and subsequently classifying them with a differential mobility analyzer (DMA). Then, after mixed well with a dilution air, particles are delivered to the test EEPS and reference CPC simultaneously. By using a reference CPC that has been calibrated with traceability to a national or international standard (e.g., AIST's primary standard), the test EEPS calibrated by this method will have metrological traceability to the standards with respect to particle number concentration.

We also evaluated the particle size distribution measured by EEPS using polydisperse particles. Polydisperse particles such as poly-alpha-olefin (PAO) and soot particles of the same aerosols are measured in parallel by the test EEPS and a reference SMPS. The reference SMPS was calibrated using monodisperse particles and the reference CPC.

We will report the results of the two kinds of tests and their uncertainty evaluation.

Characterization of Oxygenated Organic Coating on Black Carbon Particles using Soot Particle Aerosol Mass Spectrometer

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Abstract:

Atmospheric black carbon (BC) can have significant impact on climate and human health. Oxygenated organic coatings can be formed on BC surface via oxidation of volatile organic compounds (VOCs). These coatings can modify the physical and chemical properties of BC thus affecting BC environmental fate and impacts. In particular, hygroscopic and oxygenated organic coatings can modify the optical properties and cloud formation potential of atmospheric BC. Characterization of organic coatings on BC particles is, however, a great analytical challenge due to the complex organic coating mixture. Better understanding toward the coating material can improve quantification the fate of organic aerosol (OA).

This work aims to characterize oxygenated organic coatings on BC particles using the soot-particle aerosol mass spectrometer (SP-AMS) that was configured to detect BC containing particle and the associated organic materials exclusively. Laboratory generated BC particles with different oxygenated organic coatings including short chain carboxylic acids and sugars were characterized in real-time manner using the SP-AMS. While an infrared (IR) laser vaporizer of SP-AMS can heat up BC core to ~4000oC to facilitate flash vaporization, organic coating can be vaporized at much lower temperature (e.g., 100-200oC) when the BC core is gradually heating up. Elemental analysis of O:C and H:C was performed to characterize the chemical properties of the organic coatings.

Our preliminary results of the analysis of 18 different oxygenated organic coating materials show that the fragmentation pattern of organic coatings that vaporized by the IR laser vaporizer are significantly different to those of pure organic particles that vaporized by the tungsten vaporizer used in the standard aerosol mass spectrometer (AMS). The possible reason is that the tungsten vaporizer is operated at 600oC whereas the organic coating can be vaporized at a lower temperature by the IR laser vaporizer (i.e., soft vaporization condition), resulting in less fragmentation during ionization. Using the existing correction parameters for the elemental analysis of standard AMS measurements, O:C and H:C ratios of organic coatings were under- or over-estimated by approximately 20-30%. Note that the discrepancies between the tungsten and laser vaporization can be instrument and chemical dependent.

Our findings suggests the importance of developing new parametrization for elemental analysis of organic coatings data generated by the laser vaporization approach. We will discuss the new parameterization based on our observation on urban aerosol particles and laboratory-generated SOA mixtures. The improved understanding toward this discrepancy could help to better characterize organically coated BC particles, especially in the urban and industrial regions with strong combustion emissions.

Investigation of influence factors in ionized aerosol by secondary electrospray ionization mass spectrometry

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Abstract:

As a soft ionization technique, secondary electrospray ionization has shown great advantages in the analysis of complex samples like aerosols without pretreatment, and thus aroused concern especially for online monitoring of reactive species involved in various chemical reactions, such as the formation of secondary organic aerosols widely studied in atmospheric chemistry. However, the ionization mechanisms of SESI for aerosol particles are not well understood yet, which greatly hinders the application of the method. Thus, in this study, we tentatively explored ionization effects of SESI at the presence of different aerosol compositions. Three probe compounds, tartaric acid, malic acid and succinic acid, with different water solubility, were used. The aerosol samples were produced by a commercial generator and analyzed by SESI coupled with a high resolution mass spectrometer. The number concentration, mass concentration and surface area were obtained by SMPS. The results have shown that: (1) Succinic acid (water solubility of 80 g/L at 20 °C) aerosol gives the highest ion signal intensity while the intensity of tartaric acid (water solubility 1400 g/L at 20 °C) aerosol is the lowest. (2) When the aerosol sample containing three compounds were introduced, ion suppression have not been observed. (3) A correlation value of $R^2 = 0.99$ is obtained between the ion signal intensity and the particle surface area. The results will be further analyzed by considering the synergetic effects of water solubility and proton affinity of the compounds. We hope this work will eventually provide helpful information on the better understanding of quantitative analysis of components in the aerosols by using SESI-MS.

Development of a multi-nozzle virtual impactor system for bio-aerosol sampling

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Abstract:

Virtual impactors have the characteristics of sampling aerosol particles and discharging the particles with larger aerodynamic diameter than the cut-off size through the minor flow at a highly concentrated state. In this study, aiming at collecting a large amount of aerosol particles carrying viruses caused by human respiration or cough, a specially designed virtual impactor system was developed. For this purpose, virtual impactors having cut-off diameter of 0.3 μm and concentration ratio of 13.6 times was designed. Five-stages of multi-nozzle configuration were adopted to achieve a high sampling flow rate of 170 LPM with a low cut-off diameter of 0.3 μm . Clean air was introduced near the wall of the virtual impactor to minimize wall loss and further reduce the cut-off diameter. The performance of the multi-nozzle virtual impactor system was numerically and experimentally verified. This work was supported by the National Research Council of Science & Technology (NST) grant by the Korea government (MSIP) No. CRC-16-01-KRICT. ysjnuri@hayang.ac.kr.

Sharpness improvement of virtual impactor collection efficiency through parameter optimization

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Abstract:

Virtual impactors are used to classify particles with aerodynamic diameters greater than the cut-off size and concentrate those particles in the minor flow utilizing inertia. However, commonly used virtual impactors have the disadvantage that the minor flow contains particles whose aerodynamic diameters are much smaller than the cut-off diameter, and this problem is a stumbling block to the particle size classification. In this study, a clean air core which is placed at the centerline of the virtual impactor was introduced to minimize the fine particle contamination of the minor flow. The performance of the virtual impactors with the clean air core was evaluated in terms of the sharpness of collection efficiency curve. It was found that the sharpness could be influenced by the operating conditions and geometrical parameters of the virtual impactor. Therefore, a parametric study was carried out to obtain the optimum sharpness value. The factors affecting the sharpness were found to be diameter, depth, and flow rate of the clean air core. The influence of each factor was evaluated by using the method of DOE (design of experiments), and the optimization was performed by selecting the main factors among them. As a result of the optimization, the most efficient operating condition of the clean air core virtual impactor was obtained, and verified both numerically and experimentally. This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning, Grant number: 2017R1A2B2006927. ysjnuri@hanyang.ac.kr.

Igor programs for atmospheric data processing and visualization

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Abstract:

IGOR Pro is a scientific data analysis software, numerical computing environment and programming language that runs on Windows or Mac operating systems.

Igor-based toolkits had been developed for atmospheric applications, e.g. PMF/SoFi for aerodyne AMS and PAPI for DMT SP2. A set of Igor programs for atmospheric data processing and visualization had been developed in our group, including Scatter Plot, MRS, HistBox, SMPS toolkit, RT-ECOC toolkit, Aethalometer Data Processor, MA toolkit, DRI 2001A data Sorter, and Mie scattering. These programs can help to perform efficient data processing and fast batch plot generations. These programs can be downloaded and used freely from the internet.

Characterization results of new versatile Water-based Condensation Particle Counter

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Abstract:

A new water-based CPC (WCPC) has been developed and was first shown at the International Aerosol Conference 2018 in St. Louis, MO, USA. The preliminary characterization will now be supplemented by additional data characterizing the counting efficiency, concentration range, comparison to other reference counters, and the influence of aerosol material effects.

The new technical design has been initially developed by Aerosol Dynamics, CA, USA, and improves the flexibility and stability of prior water-based CPCs. Nanoparticle research and long-term ambient air quality monitoring are applications for which water-based CPCs are particularly valuable.

The counting efficiency is a characteristic of all CPCs. It is dependent on particle size in the range of very small nanoparticles and typically constant for larger particles up to $>1 \mu\text{m}$. The new WCPC has flexible counting efficiency settings. This means that this characteristic can be changed by the researcher, reaching down to close to 1 nm. The results presented here will establish standard counting efficiency settings for $\sim 2 \text{ nm}$ and 7 nm (50% efficiencies) and characterize the counting efficiency for various particle sizes at each setting. This provides a starting point for researchers who then could establish their own settings and characterize the response curve. At the two chosen settings we will also present responses to different aerosol materials, such as sodium chloride, sucrose and others.

Further characterization results include the applicable concentration range, results from monitoring urban air aerosol as well as different laboratory tests.

In addition, stress tests have been conducted to investigate the stability of the WCPC. In laboratory setups, such as aerosol simulation reactors, short-term pressure fluctuations can occur when pumps or valves are switching to change conditions. This CPC model has been challenged with over 1000 cycles of temporary inlet blockage to simulate steep aerosol pressure fluctuations. During this test the CPC concentration reading was continuously compared to a free sampling reference CPC. The ratio of the two CPCs stabilized quickly after each inlet flow blockage and returned to a consistent level of good agreement.

Sampling performance of the traditional EPA 16.7 L/min PM10 and PM2.5 Inlets

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Abstract:

The louvered 16.7 L/min PM10 inlet and the PM2.5 inlet such as well impactor ninety-six (WINS) or very sharp-cut cyclone (VSCC) are commonly used in PM2.5 FRM samplers or FEM monitors to classify particles smaller than 10 and 2.5 μm , respectively, for further analysis. Their sampling efficiencies are influenced by particle bounce, re-entrainment, and overloading since these inlets are types of inertial classifiers. In this study, the sampling performance of the traditional PM10 and PM2.5 inlets was tested in the field for a long sampling period. Then, a modified PM10 (M-PM10) inlet with an oil-soaked glass fiber filter substrate (GFFS) supported by an oil-soaked porous metal disc and the PM2.5 modified WINS (M-WINS) with a wetted GFFS were developed to eliminate the particle bounce and overloading effects. The results show that the traditional uncoated PM10 inlet which is cleaned initially but not cleaned daily afterward oversamples PM10 concentration after one 24-hr sampling day and has the high positive average sampling bias during 14 sampling days due to particle bounce and re-entrainment. The grease-coated PM10 inlet but not cleaned daily shows a better performance with a smaller sampling bias, but it still oversamples PM10 concentrations after the first three 24-hr sampling days and then undersamples after ten days due to particle bounce and overloading effects, respectively. In comparison, the developed M-PM10 inlet shows a good performance with a small average sampling bias during 34 sampling days since vacuum oil wicks up through the deposit to eliminate particle bounce and overloading. Also, the performance of the uncleaned PM2.5 VSCC which is claimed not to be affected by the particle loading effect is not good since fluctuations in measured PM2.5 concentrations are found after five sampling days as compared to the concentrations of a VSCC which is cleaned daily. Likewise, the PM2.5 WINS without regular replacement of the well shows the increase in the negative sampling bias to 20% after 17 continuous sampling days since the particle mound forms on the substrate leading to overloading effect. On the other hand, the M-WINS which uses water to wash the wetted GFFS continuously or oil to clean the substrate periodically shows a good sampling performance since it measures PM2.5 accurately for a longer sampling period without the need of maintenance. In short, it is suggested that the oiled M-PM10 inlet and the oil- or water-wetted M-WINS can be used to replace the

traditional EPA PM10 and PM2.5 inlets and for long-term sampling of over one month without the frequent maintenance need.

Identification and quantification of ambient acidic ultrafine particles using a self-developed diffusion sampler

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Abstract:

ABSTRACT:

Acidic ultrafine particles (AUFPs) are ubiquitous in the atmosphere with significantly adverse impact on human health, visibility, and climate. However, no reliable measurement techniques are able to assess the existence of AUFPs and quantify the number concentration of AUFPs. In this study, our aim is to certify the existence of AUFPs in the air and obtain the number concentration of AUFPs with the use of nano-iron film detectors and a diffusion sampler (DS). Standard sulfuric acid (H₂SO₄)-coated particles were generated using the Standard Acidic Particles Generation (SAPG) system and deposited on the surface of nano-iron film detectors to generate reaction spots. The reaction spots, apparently different from those caused by non-acidic particles, were scanned using the Atomic Force Microscope (AFM) so as to obtain shapes and sizes of the acidic particles. To validate this method, two field measurements were conducted. One was from Jan. 06 to Feb. 19, 2017 on the rooftop of a 12-floor building (~36 m above the ground) on campus and the other was between Nov. 23 to Dec. 14, 2017 at a roadside site near a Cross Harbor tunnel. In total, four and five sets of samples were collected and scanned, respectively. The nano-iron film detectors were deployed inside the DS at three different locations in a flat and rectangular channel to collect the ultrafine particles. The detectors were then scanned by the AFM to numerate and distinguish the acidic particles from the non-acidic particles according to the reaction spots. Based on the semi-empirical equation for the collection efficiency of particles at three different locations in the DS, the number concentrations of acidic particles and non-acidic particles were both quantified from AFM images. Results indicated that the method was reliable for the measurement of AUFPs in the atmosphere, and the number concentration of AUFPs at the roadside site ($5.13 \pm 4.65 \times 10^2 \text{ cm}^{-3}$) was much lower than that on the rooftop ($3.25 \pm 2.43 \times 10^3 \text{ cm}^{-3}$).

KEYWORDS: Acidic ultrafine particles (AUFPs); Nano-iron film detector; Standard Acidic Particles Generation (SAPG) system; Diffusion sampler (DS)

ACKNOWLEDGMENT:

This work was supported by the Environment and Conservation Fund (ECF) of the Hong Kong Special Administrative Region (ECF 59/2015).

A novel electrostatic particle collector for quantitative microscopic analysis of the size distribution and number concentration of aerosol particles

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Abstract:

Recently, the health risks of nanomaterials have garnered concerns. The definition of nanomaterials proposed by the European Commission in 2011 is that nanomaterials are those with the number fraction of primary particles with diameters equal to or less than 100 nm is 50 % or greater. To measure the number fraction of primary particles, electron microscopic analysis is required. Current methods for the preparation of samples for microscopic analysis is by dispersing solid materials into liquid, dispensing a drop of the dispersed liquid onto a substrate, and drying up the drop on the substrate. Microscopy samples prepared by this method, however, have some drawbacks. When the particles in the test material has a polydisperse size distribution, smaller particles may be hidden underneath larger particles. In addition, during drying up the substrate, particles may aggregate on the substrate.

We developed a novel particle collector that deposits particles onto a substrate by an aerosol technique with little hiding and aggregation and allows determination of the size distribution of introduced aerosol particles by analyzing the image of collected particles by electron microscopy. A material to be tested is dispersed in a liquid first, and then the dispersion liquid is sprayed in a carrier gas as an aerosol by using an electrical spray or other atomizing device. Then the aerosol is charged with a bipolar charge conditioner and sent into the collector.

The collector is essentially a parallel-plate electrostatic precipitator. That is, the flow channel in the deposition section has a rectangular cross-section and an electrostatic field is created between two electrode surfaces; one is the collection surface electrically grounded and the other is the repulsion electrode with a high voltage applied. This configuration forms an electric field perpendicular to the aerosol flow in the collector. While the introduced charged particles flow through the collection section, they are pushed to the collection surface by a Coulombic force and collected.

The advantage of the design of this collector is that a simple electrostatic model can describe the collection mechanism: 1) The collection area of particles of a certain electrical mobility is determined by the electrical field strength, the mean velocity of an aerosol flow, and the width and height of the flow channel of the collector, 2) the number density of particles collected is determined by the electrical

mobility, the electrical field strength, the flow rate, the particle number concentration, and the collection time, and 3) the number density is uniform in the collection area for particles of a certain electrical mobility.

To evaluate the performance of the new collector, several sizes of mono-disperse particles are collected on silicon wafers which were placed on the collection electrode under various electrical field intensities. Then the particles collected on the silicon wafers were analyzed by scanning electron microscopy. The collected number density obtained by SEM analysis agreed with the density predicted by the model above within $\pm 4\%$.

A Cascade Air Sampler with Multi-nozzle Inertial Filters for PM_{0.1}

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Abstract:

A multi-nozzle (3-nozzle) geometry was applied to an inertial filter stage of an existing cascade air sampler, which was developed by the authors and consists of 4-impactor stages (PM₁₀/2.5/1/0.5) followed by a single nozzle inertial filter stage (PM_{0.1}), which consists of webbed stainless fibers plugged in a circular nozzle. The purpose of this study is to improve the sampler so as to provide multi-samples at the inertial filter stage, which allow us to analyze multi-chemical components in particles in an important size range of 0.1-0.5 μm . The separation performance and pressure drop of a newly designed inertial filter stage of 3-nozzles were examined and compared with those of a single nozzle inertial filter stage. The cascade air samplers of 1- and 3-nozzle inertial filter stage were then run together for a selected period to collect ambient particles to discuss a difference in collected particle mass between 3-nozzles and to compare the collected mass of particles on each stage between 2 samplers. Total carbon was analyzed to discuss a difference between 3-nozzles, the uniformity of PM_{0.1} collection on a filter downstream the inertial filter stage and the compatibility between 2-samplers based on the chemical component. By carefully adjusting the amount of webbed fibers and the uniformity of plugged fibers in a nozzle for each inertial filter of the 3-nozzle stage, the separation performance was confirmed to be almost same between 1- and 3-nozzle geometries at about 10% less pressure drop for 3-nozzles. Differences in the collected particle mass and the total carbon between 3-nozzles were confirmed to be acceptable. Differences in the collected particle mass and the total carbon between 1- and 3-nozzle. The uniformity of PM_{0.1} collected on a backup filter was fairly good. This may indicate a practical applicability of 3-nozzle geometry. The multi-nozzle geometry of the inertial filter was shown to keep an important advantage of the inertial filter, or, a low pressure drop for PM_{0.1} separation, and to provide more possibilities of the analysis of various chemicals.

Development and Performance Evaluation of Real-time Nano-Particle Sizer

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Abstract:

Precise measurement of particle size distribution is the most important matter when it comes to environmental and human health-related issues. Generally, to measure particle size distribution in sub-micron size area, scanning mobility particle sizer (SMPS) has been used. However, it is hard to adapt the transient condition that particle concentration changes continuously because SMPS essentially needs a couple of minutes to scan particle size distribution. In this research, we have developed a new Nano-Particle Sizer (NPS) which consists of multi-port differential mobility analyzer (MP-DMA) with multiple sampling ports and multi condensation particle counter (M-CPC) that measures particle classified from each sampling port at the same time. NPS has been evaluated its performance by the mono-dispersed and poly-dispersed particle. M-CPC could condense particle size above 10 nm completely and detection efficiency showed good linearity to particle number concentration up to 25,000 #/cc. Geometrical standard deviation of each sampling port of MP-DMA was in the ranges of 1.035~1.066. Transmission efficiency of each sampling port showed good repeatability. For measurement using poly-dispersed particle, NPS showed good conformity with TSI-SMPS under steady-state condition. However, under the transient condition, NPS showed a more reliable result than TSI-SMPS.

A novel quartz crystal microbalances cascade impactor for real-time particle mass distribution measurement

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Abstract:

Cascade impactor are widely used to measure particles mass distributions. However, traditional impactors generally required sampling for long periods of time so that the aerosol mass collected on the impaction substrate of each stage can be weighted. Recently a new instrument named QCM-MOUDI (MSP Inc., USA) was invented, of which the QCMs (Quartz Crystal Microbalances) are flush-mounted to the MOUDI (Micro-Orifice Uniform Deposition Impactor) impaction plates. The impactor has a 2.5 μm inlet and 6 QCM stages with well-defined, sharp collection efficiency curves with calibrated cut-points of 960, 510, 305, 156, 74 and 45 nm at 10 L/min inlet flow rate. QCM-MOUDI is a breakthrough in cascade impactor technology for real-time size-fraction and mass measurement of aerosols. However, the stability and data quality of this instrument need to be tested, especially in the polluted atmosphere.

A comprehensive campaign was conducted in a regional site located on the northeast of Yangtze River Delta during 15th May to 15th June, and we used three instruments to obtain particle mass concentration. QCM-MOUDI was used to measure particle mass distribution, and TEOM to measure PM_{2.5}, and two sets of SMPS plus APS (TSI Inc., USA) to obtain particle number size distribution (PNSD) and calculated mass concentration based on some assumptions. The good agreements between QCM-MOUDI and the other instruments were observed from the beginning to the end of this campaign. Pearson correlation coefficient was 0.80 between QCM-MOUDI and TEOM, and 0.82 between QCM-MOUDI and PNSD instruments. The average PM_{2.5} measured by QCM-MOUDI, TEOM, PNSD instruments was 53.7 ± 46.6 , 50.2 ± 43.6 , $60.7 \pm 48.8 \mu\text{g}/\text{m}^3$ respectively. Four pollution episodes were caught during this campaign. Particles larger than 510 nm dominated the particle mass concentration in clean periods, while the percentage of particles in the size range from 160 to 510 nm increased rapidly in polluted periods, indicating a fast transition from gaseous precursors to particles in this size range.

Improving the accuracy of particle number size distribution by measuring charged particles of both polarities

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Abstract:

Conventionally, electrical mobility particle spectrometers measure charged particles of one polarity, which may suffer from variations in charge fractions. Measuring charged particles of both polarities is a new method to improve the accuracy of particle number size distribution (PNSD), which is already verified by theoretical analysis and laboratory-generated aerosols but not applied to field campaign yet. This study applied this new method to measure particle size distribution using a modified SMPS (TSI Corp), which can change the voltage polarity of a long DMA (Model 3081, TSI Corp.) to select positively or negatively charged particles alternatively. The ion mobility ratio was estimated based on the raw PNSDs, and the integral property, total particle number concentration (PNC), was used to evaluate the application of this new method to field campaign.

Either a 85Kr (2 mCi, Model 3077, ~14 years, TSI Corp.) or soft X-ray (SXR, Model 3088, TSI Corp.) neutralizer brought aerosols into a stationary charge state before the DMA, and a CPC (Model 3772, TSI Corp.) would detect the concentration of DMA-selected particles (Scanning mode) and total concentration (CPC mode) alternatively. A diffusion dryer was placed before the neutralizer inlet to make sure the relative humidity was less than 40%. The sheath and aerosol flow rate were 3 lpm and 0.3 lpm respectively, and particles with the size range of 12~800 nm were measured. This modified SMPS has monitored the particle size distribution of ambient air for several months.

Results showed that the estimated mobility ratio of positive and negative ions generated in 85Kr and SXR neutralizer was around 0.73 and 0.95 respectively, and the ion mobility ratio was constant during the campaign with the temperature and pressure varying within a typical range. This demonstrated that the change of ion mobility would not be a concern under typical weather conditions. For 85Kr case, the integrated PNC of inverted PNSDs with the conventional Wiedensohler's approximation to calculate charge fractions varied a lot from the measured PNC. The sum or average inversion method can reduce the discrepancy between the inverted and the measured PNC. For SXR case, charge fractions in Tigges et al. (2015) were used to get the inverted PNSD, and the integrated PNCs positively charged particles, negatively charged particles and sum inversion were all close to the measured PNC due to the nearly-equal positive and negative charge fractions. In conclusion, to measure charged particles of both polarities is an efficient way to improve the accuracy of particle number size distribution, especially when the charge fractions of particles in the charger are uncertain.

Operating a Differential Mobility Analyzer (DMA) for Size Selection of Nanoparticles at low temperature

GUORONG CHEN

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Abstract:

Particle size selection using the Nano-Differential Mobility Analyzer (Nano-DMA) at low temperature is beneficial for investigating physicochemical processes of aerosol particles in the earth's atmosphere, as many areas on the planet is colder than normal room temperature. We developed a laboratory experimental setup to operate the Nano-DMA at temperature as low as $-5\text{ }^{\circ}\text{C}$. A refrigerated and heating bath circulator is connected to a radiator, which was installed in a thermally insulated chamber to obtain the required stable temperature with accuracy of $0.1\text{ }^{\circ}\text{C}$. Air in the chamber was circulated by a fan to achieve uniform temperature distribution. A small amount of dry air was supplied to the chamber to avoid water condensation. The sheath and sample flows for the DMA were passed through coils of copper tubing to equilibrate temperature before entering the classifier. Classification performance of aerosol particles under different temperature range was investigated using a tandem DMA setup.