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Dual-light inspired in-situ antibacterial activity of chitosan-assisted MoS_2 nanosheets

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Introduction: Increasing osteoporosis-related fractures caused by the increasing aging population and orthopedic diseases have been bringing about booming demand for artificial implant materials[1,2]. However, the surface of these artificial implants often provides an hospitable place from bacterial attachment and growth after implantation in vivo. Once bacterial biofilm forms on the surface, it has to remove these implants through second surgery because it is very difficult to treat it by antibiotics[3-5]. Herein, we for the first time to endow the implant materials (biomedical titanium implant material) with excellent antibacterial ability of through inspiring both photocatalytic and photothermal properties of CS/MoS_2 hybrid coating by short-term dual lights irradiation simultaneously.

Materials and Methods: Electrophoretic deposition was applied to introduce chitosan and MoS_2 onto titanium substrates. A scanning electron microscope (SEM; JSM6510LV, Japan) was employed to analyze the morphology of the samples. A transmission electron microscope (TEM; Tecnai G20, FEI, USA) was used to observe the microstructures of the CS/MoS_2 in the coatings. X-ray photoelectron spectroscopy (Thermo Fisher Scientific 250Xi, USA) and a Fourier transform infrared spectroscopy (FTIR, NICOLET iS10) in the range from 400 to 4000 cm^{-1} was introduced to identify the chemical compositions of the hybrid coatings. The structural changes in the MoS_2 before and after exfoliation were elucidated by Raman spectroscopy (InVia Reflex, Renishaw) at room temperature. Ultraviolet−visible−near-infrared spectrophotometer (UV-3600, Shimadzu, Japan) was used for the absorbance measurements. *E. coli* and *S. aureus* was used to evaluate the antibacterial activity in vitro. Antibacterial assay in vivo was executed in rats.

Results and Discussion: The results demonstrated that MoS_2 nanosheets were obtained by stripping and the CS/MoS_2 was successfully grafted onto the surface of the Ti. (Figure 1). Then the good biocompatibility and excellent antimicrobial activity in vitro and vivo were evidenced inspired by dual light (660nm visible light and 808 NIR).

Conclusion: In conclusion, we have constructed dual light inspired antibacterial system based on biocompatible CS/MoS_2 nano hybrid coating in the surface of Ti, which exhibited significant photocatalytic activity and photothermal efficacy. Inspired by 660 nm VL irradiation, the sample facilitate oxygen in water transform into single linear active oxygen $^1O_2$, which disrupted integrity of the bacterial cell walls. Meanwhile, 808 nm NIR induced the hyperthermia to inhibit the biological activity of bacteria. The vitro antibacterial results reveal that being inspired by dual light acquired a good antibacterial effect in a shorter time compare to the 660 nm VL irradiation process or 808 nm NIR irradiation treatment alone. Besides, the animal experiment in vivo also proved this result and indicate the good biocompatibility which were agreement with the cytotoxicity assay in vitro. Moreover, the sample also show certain osteogenesis capability. Consequently, these results suggest that this antibacterial system has the great potential for in-situ antibacterial of medical equipment and subcutaneous tissue antimicrobial, anti-inflammatory and bone repair.

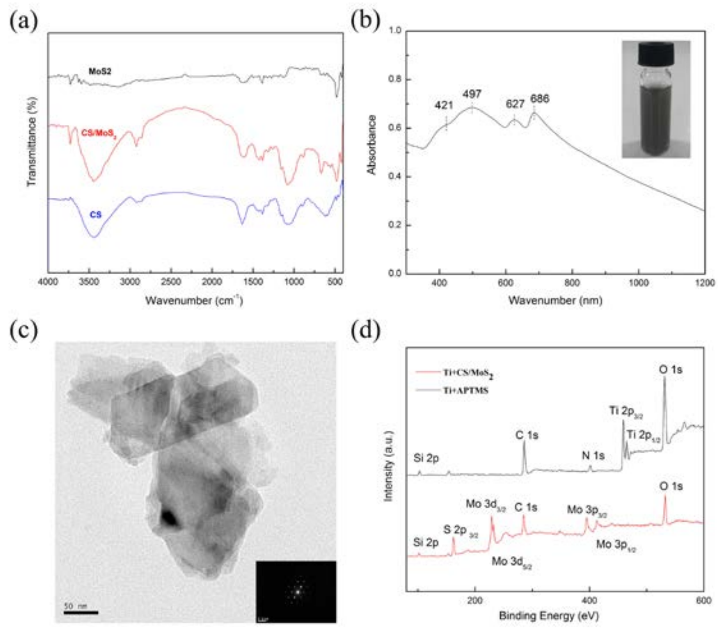

Figure 1. (a) FT-IR spectra for native MoS_2, chitosan and CS/MoS_2. (b) UV-vis-NIR spectrum of CS/MoS_2, and a photo (Inset) of CS/MoS_2 dispersion in water. (c) TEM image and the corresponding selected area electron diffraction (SAED) patterns of CS/MoS_2. The scale bar is 50nm. (d) XPS survey plot of Ti + APTMS and Ti + CS/MoS_2.

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