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# A hybrid zinc ion-doped g-$C_3N_4$ and graphene oxide as novel antibacterial nanoplatform through oxygen stress and hyperthermia induced by light

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**Introduction:** Photodynamic therapy (PDT) and photothermal therapy (PTT) are new effective Gram-positive and Gram-negative bacterial killiing methods [1]. Graphitic carbon nitride(g-$C_3N_4$), a novel low-toxicity inorganic photocatalyst [2], is limited employed in biomaterials as its low photocatalyst activity and application in visible light, therefore it has relatively poor bactericidal activity to *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) . Also, the reactive oxigen species (ROS) generated by g-C3N4 is $\cdot O^{2-}$ [3], that it has weak inactivation activity to *S. aureus* and *E. coli*. To overcome these shortcomings, A zinc ion doped g-$C_3N_4$ and graphene oxide 2D-2D hybrid nanomaterial (MPCN-Zn@GO5%, MPCN-Zn@GO10%, MPCN-Zn@GO20%, MPCN-Zn@GO40%) is designed through chemical vaper deposition and ultrasonic dispersion synthesis. The nanoplatform photocatalyst activity is greatly promoted than single g-$C_3N_4$. Herein, *S. aureus* and *E. coli* are killed more than 99% by synergistic effect of PDT and PTT of oxygen stress and hyperthermia which can bring damage to bacterial membrane.

**Materials and Methods:** The morphology and microstructure of as-prepared nanomaterials are investigated by scanning electron microscopy (SEM, JSM7100F and JSM6510LV,JAPAN) equipped with energy-dispersive spectroscopy (EDS) and transmission electron microscope (TEM;Tecnai G20, FEI, USA). Selected area electron diffraction(SAED) is used to determine the microstructures of g-C3N4 and graphene oxide. The phase structure is obtained by X-ray diffraction (XRD, D8A25, Bruker, Germany) in continuous mode, scanning 2θ from $10^o$ to $70^o$ with a step size of $0.17^o$. The composition and structure of MPCN-Zn@GO are determined by Fourier transform infrared spectroscopy (FT-IR, Nicolet 570).

**Results and Discussion:** The morphology ,microstructure ,phase structure and composition are presented in Figure .1(Fig .1). From the Fig .1 we can estimate the MPCN-Zn@GO is sucessfully synthesised. So that it has well photocatalyst activity and bacterial inactivation activity as the hybrid nanomaterials.

**Conclusion:** In summary, the prepared four nanomaterials have effective antibacterial properties towards *S. aureus* and *E. coli* through photodynamic therapy and photothermal therapy. Under visible light of red light (660nm), the MPCN-Zn@GO inspires ROS of weak $\cdot O^{2-}$ to damage bacterial membrane. Under near-infrade light (808nm), the MPCN-Zn@GO triggers hyperthermia to kill partial bacteria. Under the red light and near-infrade light, the MPCN-Zn@GO can kill almost all of the bacterial. Consequently, the harmfulless nanoplatform can employ red light and near-infrade light to synergistically kill Gram-positive and Gram-negative bacteria and it don't generate cell toxicity, suggesting that it has great potential application for antibacterial in *vivo* and *vitro*.

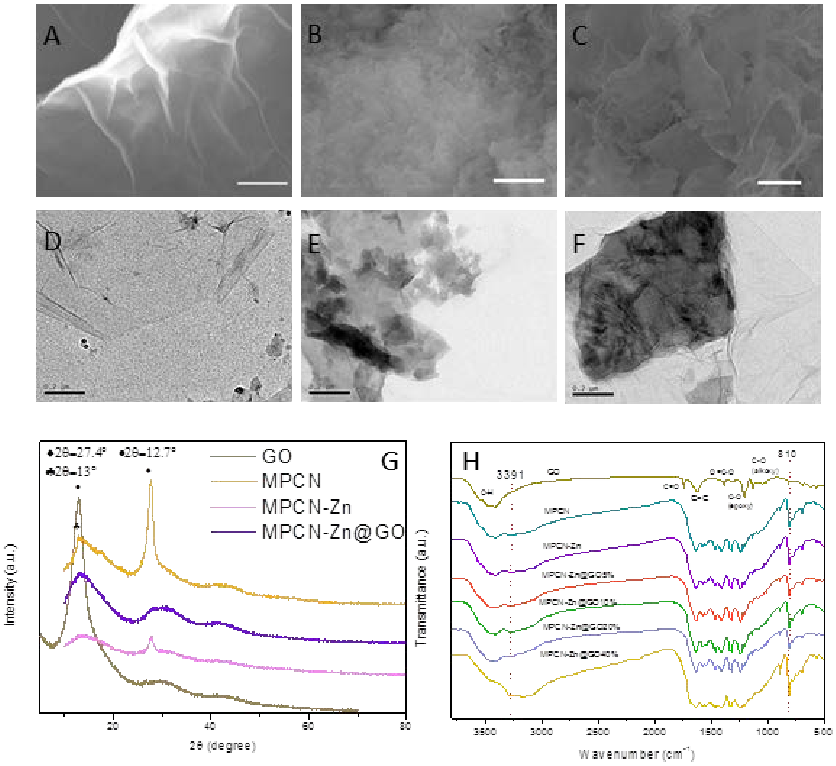


**Figure 1** The morphology and microstructure and phase structure or composition is presented. A-C show the morphology of GO, MPCN, MPCN-Zn@GO, respectively. D-F show the microstructure of GO, MPCN, MPCN-Zn@GO. G show the phase structure pattern of GO, MPCN,MPCN-Zn@GO, respectively. H show the composition and structure of GO, MPCN, MPCN-Zn, MPCN-Zn@GO5%, MPCN-Zn@GO10%, MPCN-Zn@GO20%, MPCN-Zn@GO40%, respectively.

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