Exploring the visible light photocatalytic activity of the ZnO-RGO hybrid-nanostructures by sol-gel process

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ABSTRACT

Carbon-based material, like the graphene, exhibits the unique 2-D structures, e.g., sp^2-conjugated carbon atoms, highly electronic conductivity, larger specific surface area, better chemical stability. Hence, it attracts various attentions in many fields, such as the photocatalysts, solar cells, energy storage, etc. Zinc oxide (ZnO) is an n-type semiconducting material with a wide direct band gap (3.3 eV), hexagonal wurtzite structure and higher exciton binding energy (60meV), and has been applied in the field of photocatalyst, optoelectronic devices, gas sensors, and solar cells. In this study, the pristine and ZnO-RGO hybrid-nanostructures were fabricated by sol-gel method at the ambient environments. Subsequent baking was conducted at the 500℃ under 4×10^{-3}torr.

XRD patterns showed that peaks of (100), (002), (101), (102), (110), (103) planes belonged to the pure ZnO nanoparticles as the wurtzite structure, but no RGO-related peaks appeared at 24° of the ZnO-RGO hybrid-nanostructures. The SEM images revealed that the sheet-structures appeared in the adding RGO samples and the TEM-SAD showed the RGO patterns, suggesting that the RGO was covered by the ZnO nanoparticles which has confirmed the XRD results. Raman spectra exhibited the decreasing ratio of I_D/I_G from 1.2 to 0.8 while the ZnO combined with the RGO, meaning that ZnO fixed the defects inside the RGO and increased the sp^2-carbon domain.

UV-visible absorbance spectra revealed the characteristic peak of ZnO at 375nm, and the absorbance increased with the increasing RGO concentrations. PL spectra exhibited two emission regions at NBE and DLE, and displayed the decreasing tendency while the RGO contents increased, indicating that the recombination of electrons and holes was hindered by the adding of RGO. The specific surface area (BET) showed the increasing profile from 4 to $18.5m^2/g$ while the RGO contents was from 0 to 6400ppm, while the grain size decreased from 31 to 26nm. The results suggested that the RGO could inhibit the grain growth of ZnO, therefore, the BET values increased. The visible light photocatalytic tests revealed that the efficiency of pristine ZnO, $ZnO\text{-}RGO_{400ppm}$, $ZnO\text{-}RGO_{800ppm}$, $ZnO\text{-}RGO_{1600ppm}$, $ZnO\text{-}RGO_{3200ppm}$, $ZnO\text{-}RGO_{6400ppm}$ were 10%, 50%, 94%, 95%, 96%, and 94%, respectively, after 15min illuminating time. Furthermore, the rate constant was smaller than $0.012min^{-1}$ while the RGO was lower than 400ppm. On the other hand, the rate constant larger than $0.04min^{-1}$ while the RGO was higher than 800ppm. Both of which confirmed the results of photocatalytic efficiency. In summary, the RGO should be able to inhibit the recombination of electrons and holes, and increase the BET values, as followed by the enhancing of the photocatalytic efficiency under the visible light.

Keywords: RGO, ZnO-RGO nanostructures, photoluminescence, photocatalysts

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