

Fabrication of GaOOH-Au Nanoheterostructures and Their Photocatalytic Performance in Methanol Oxidation

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GaOOH, a wide bandgap semiconductor material, is usually used as a precursor for the synthesis of Ga₂O₃. GaOOH has a d¹⁰ electron configuration having high degree of deformation of unit cell that can produce a strong dipole moment to prompt the electron-hole separation.¹ As a result, GaOOH is regarded as a promising photocatalyst in relevant redox reactions.

In this work, GaOOH nanorods (NRs) with considerable uniformity in size were prepared via a facile wet-chemistry chemical precipitation approach. It was found out that the pH value of the reaction greatly influenced the morphology of the resultant GaOOH nanostructures. To further the charge separation efficiency of GaOOH NRs, Au nanoparticles (NPs) were deposited on the surface of GaOOH NRs through a chemical reduction method. Here Au NPs play an important role in reducing charge recombination of GaOOH.² The TEM images shown in Figure 1 clearly displayed the uniform distribution of Au NPs on GaOOH NR surface, in which the more initial HAuCl₄ employed, the more Au NPs coated on GaOOH NRs. However, significant aggregation of Au was observed when the content of Au reached 4.0 mol%.

Owing to the difference in band structures between GaOOH and Au, the photoexcited electrons of GaOOH would preferentially transfer to Au, leaving photogenerated holes in GaOOH to achieve charge carrier separation. The photocatalytic performance of the samples was evaluated by the photooxidation of methanol which yields formaldehyde. The thus-formed formaldehyde can then react with acetylacetone and excess ammonium acetate to form a yellow colored product (diacetyldihydrolutidine, DDL) that can be quantitatively characterized by measuring its absorbance at 404 nm.³ Figure 2 shows the formation of DDL as a function of irradiation time over different samples. As compared to the relevant commercial products such as P-25 TiO₂ and Ga₂O₃ powders, the synthesized GaOOH-Au sample exhibited a superior photocatalytic performance toward methanol oxidation, and could be attributable to the effective charge separation that took place at the interface of GaOOH-Au. The current GaOOH-Au sample may find potential applications in relevant photocatalytic reactions such as water splitting and photoexcited electron storage.

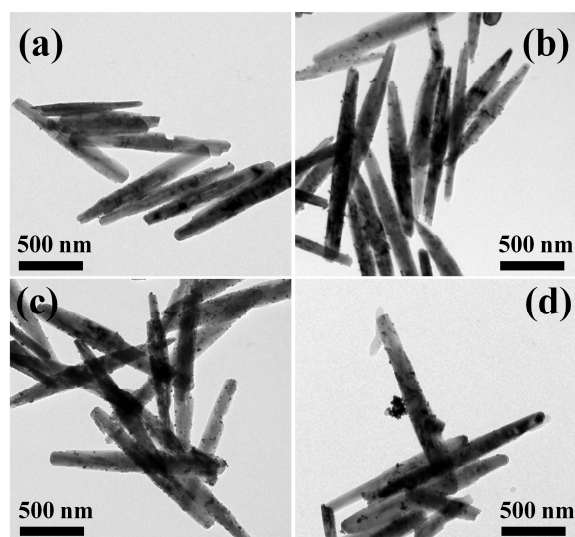


Figure 1. TEM images of GaOOH-Au samples with different Au concentrations: (a) 0.5 mol%, (b) 1.0 mol%, (c) 2.0 mol%, (c) 4.0 mol%.

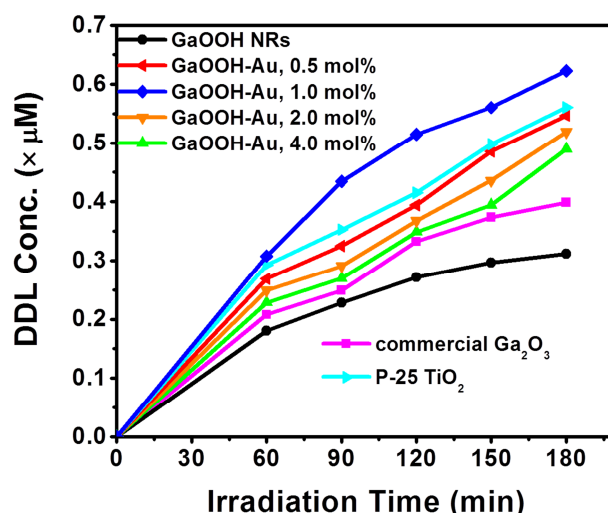


Figure 2: The plots of DDL formation vs. irradiation time for various GaOOH-Au samples.

References

- (a) Y. Inoue, *Energy Environ. Sci.* **2009**, 2, 364-386.
(b) J. Sato, H. Kobayashi, K. Ikarashi, N. Saito, H. Nishiyama, Y. Inoue, *J. Phys. Chem. B* **2003**, 107, 7970-7975.
- (a) V. Subramanian, E. E. Wolf, P. V. Kamat, *J. Am. Chem. Soc.* **2004**, 126, 4943-4950. (b) A. Dawson, P. V. Kamat, *J. Phys. Chem. B* **2001**, 105, 960-966.
- British Standards, EN 717-1:2004