

Synthesis of an Enhanced Visible-Light Activated Hierarchical Three-dimensional Ag/TiO₂ Nanowires/Graphene Sandwich Photocatalyst

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Abstract

Developing and deploying high performing photocatalysts in full-scale treatment systems is an essential technology for removing organic pollutants from drinking water supplies and wastewater effluents. TiO₂ is considered a promising photocatalyst because of its long-term thermal and chemical stability, non-toxicity, low cost and universal applicability.¹⁻³ However, photocatalysts prepared with only TiO₂ are unable to meet requirements such as a wide optical absorption range, high charge-separation efficiency and high adsorbability of pollutants. Because of its high electric charge carrier mobility and optical transparency, intrinsic large surface and capability of chemical functionalization,⁴ graphene is an ideal material for providing mechanical support, behaving as an electric charge carrier shuttle for photo sensitizers and providing a large surface to construct photocatalysts with enhanced performance.^{2,5-7} In this study, TiO₂, graphene and Ag were combined to prepare a hierarchical three-dimensional (3-D) Ag/TiO₂ nanowires/graphene (Ag/TNWs/G) sandwich. The catalyst demonstrated that the surface plasmon resonance (SPR) effect caused by Ag nanoparticles resulted in strong and broad absorption bands in the visible light region.⁸⁻¹¹ The photocatalyst sandwich was able to decompose methylene blue (MB) more efficiently when compared to a TiO₂ nanowire / graphene (TNWs/G) complex or TiO₂ (P25). BET studies confirmed that the specific surface area (SSA) of the catalyst was a factor of approximately 5.4 greater than that of commercial TiO₂ (P25). When compared to the sandwich catalyst, the MB degraded rate was approximately 32-fold greater than for P25 and approximately 2-fold greater than for TNWs/G. Coupling the characteristics of graphene with the SPR properties of Ag nanoparticles in the 3-D hierarchical sandwich could be a promising strategy for preparing other noble and carbon based TiO₂ nanotube composite photocatalysts for degrading organic pollutants in drinking water and wastewater effluents.

References

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Figure: 3-D Ag/TiO₂ nanowires/graphene (Ag/TNWs/G) sandwich: (a) SEM image and (b) schematic model

