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Synthesis of TiO_2/Graphene Nanocomposites with Excellent Visible-Light Photocatalytic Activity Based on Chemical Exfoliation Method

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Abstract : Facile electron-hole recombination and the broad band gap are two major drawbacks of titanium dioxide (TiO_2) when applied in visible-light photocatalysis. Hybridization of TiO_2 with graphene is a promising strategy to lessen these pitfalls. Recently, there have been many reports on the synthesis of TiO_2/graphene nanocomposites, in most of which graphene oxide (GO) was used as a starting material. However, the reduction of GO introduced a large number of defects on the graphene framework. In addition, the sensitivity of titanium alkoxide to water (GO usually contains) significantly obstructs the uniform and controlled growth of TiO_2 on graphene. Here, we demonstrate a novel technique to synthesize TiO_2/graphene nanocomposites without the use of GO. Graphene dispersion was obtained through the chemical exfoliation of graphite in titanium tetra-n-butoxide with the aid of ultrasonication. The dispersion was directly used for the sol-gel reaction in the presence of different catalysts. A TiO_2/reduced graphene oxide (TiO_2/rGO) nanocomposite, which was prepared by a solvothermal method from GO, and the commercial TiO_2-P25 were used as references. It was found that titanium alkoxide afforded the graphene dispersion of a high quality in terms of a trace amount of defects and a few layers of dispersed graphene. Moreover, the sol-gel reaction from this dispersion led to TiO_2/graphene nanocomposites featured with promising characteristics for visible-light photocatalysts including: (I) the formation of a TiO_2 nano layer (thickness ranging from 1 nm to 5 nm) that uniformly and thinly covered graphene sheets, (II) a trace amount of defects on the graphene framework (low ID/IG ratio: 0.21), (III) a significant extension of the absorption edge into the visible light region (a remarkable extension of the absorption edge to 578 nm beside the usual edge at 360 nm), and (IV) a dramatic suppression of electron-hole recombination (the lowest photoluminescence intensity compared to reference samples). These advantages were successfully demonstrated in the photocatalytic decomposition of methylene blue under visible light irradiation. The TiO_2/graphene nanocomposites exhibited 15 and 5 times higher activity than TiO_2-P25 and the TiO_2/rGO nanocomposite, respectively.

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