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Electron flux at the Schottky junction of Bi NPs and MoS_2-supported RGO for degradation of Tetracycline

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In this work, a heterostructured metallic Bi/MoS_2 photocatalyst (MBi_x) was prepared via uniform decoration of plasmonic bismuth nanoparticles onto the surface of MoS_2 nanosheets. MBi_x catalysts were then loaded onto the surface of reduced graphene oxide (RGO) using a simple hydrothermal method to form RGO/MBi_x nanocomposite. RGO/MBi_x heterostructures demonstrated significantly improved photocatalytic performance for the removal of tetracycline (TC) under visible-light irradiation. The enhanced photocatalytic activity was found to be dependent on the level of Bi and RGO in the catalyst. The degradation rate over the optimum catalyst (RGO-2.5/$MBi_{1.0}$) was six-fold higher than that of pristine MoS_2. The results indicated the dual roles of the Bi nanoparticles in the RGO/MBi_x nanocomposite in improving the light-harvesting ability and charge separation attributed to the plasmon-mediated activation of the metallic Bi nanoparticles under visible light, followed by efficient electron migration among Bi/MoS_2 interfaces. The intimate interfacial contact of the metal and semiconductor allows only the electron transport from the semiconductor to metallic nanoparticles and hinders electron movement back across the Schottky barrier, resulting in significantly accelerating the carrier pairs separation and restricting the mobile charges recombination. Therefore, the built-in electric field at the junction of the Bi nanocrystals and MoS_2 can provide an interesting and efficient pathway for the photocatalytic oxidation of TC. Both of these features in synergy with the inherent characteristics of RGO as a competitive acceptor component, which provided a conduction path for the photo-induced charges, led to remarkable enhancement in the photocatalytic activity of the nanocomposite. The trapping experiments showed •OH and $\bullet O_2^-$ played a crucial role in TC photocatalytic degradation. Additionally, RGO-2.5/$MBi_{1.0}$ exhibited stable activity during the photodegradation of TC over multiple cycles. The present study could not only present a novel strategy for increasing the photocatalytic performance of MoS_2 but also display great potential for the feasibility of utilizing the abundant and low-cost Bi nanoparticles to replace the precious noble metals to promote the spectral response in the visible region.

Keywords: MoS_2, Metallic Bi, Nanoparticles, light-harvesting, Charge separation

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