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Heterojunctions for Photocatalytic Wastewater Treatment: Positive Holes, Hydroxyl Radicals and Activation Mechanism under UV and Visible Light

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Abstract:
Forming heterojunctions by coupling two or more semiconductors is an important strategy to develop stable and efficient photocatalysts able to operate both under near-UV and visible light. Five novel heterojunction systems were synthesized in the present study, using a modified sol-gel method: $Bi_2Mo_3O_{12}/TiO_2$, $ZnFe_2O_4/TiO_2$, $FeTiO_3/TiO_2$, $WO_3(US)/TiO_2$ and WO_3/TiO_2. These heterojunction semiconductors were characterized by using XRD, SEM and EDX, UV–Vis diffuse reflectance spectroscopy and BET. Their photocatalytic activities were evaluated using methyl orange (MO) degradation under both near-UV and visible light. From the various heterojunctions developed, the $WO_3(US)/TiO_2$ photocatalyst was the one that showed the highest photocatalytic efficiency with this being assigned to the formation of a double heterojunction involving anatase, rutile and monoclinic WO_3 phases. On this basis, a photocatalyst activation mechanism applicable to near-UV and visible light irradiation was proposed. This mechanism explains how the photogenerated electrons (e^-) and positive holes (h^+) can be transferred to the various phases. As a result, and given the reduced holes and electron recombination surface, hydroxyl radicals found were more abundant. To confirm this assumption, hole formation in the valence band was studied, using hole-scavenging reactions involving ion iodine (I^-), while hydroxyl radical production used fluorescence spectroscopy.

Keywords: heterojunctions, photocatalysts, titanium dioxide, visible light, tungsten trioxide, activation mechanism

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