ABSTRACT

THESIS: Tuning the Band Gap of Bismuth Vanadate via Z-Scheme Heterojunction

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Metal oxide semiconductors such as TiO_2 and ZnO have been exploited many times in photocatalysis and photoelectrochemical applications under UV light irradiation. Alternatively, new sets of metal oxide semiconductors such as Cu_2O, Fe_2O_3, and $BiVO_4$ have attracted widespread attention because of their ability to absorb light in the visible region. However, most of this category of photocatalyst is impacted by electron-hole recombination, slow charge transportation, and photo-corrosion. Furthermore, the bandgap of most metal oxides is not positioned to allow the reduction of water to hydrogen. Creating a Z-scheme heterojunction is a practical approach to total photoelectrochemical water splitting by combining a photoanode and a photocathode in one photocatalyst. This architecture allows spatial separation between the H_2 and the O_2 generation processes and improves the electron/hole separation. In this thesis, we describe a new approach to enhance the photocatalytic activity of $BiVO_4$ with other bismuth-based metal oxides, namely $Bi_2Ru_2O_7$, and $Bi_xGa_yO_z$ to produce the Z-scheme photocatalyst $Bi_2Ru_2O_7/BiVO_4$, and $Bi_xGa_yO_z/BiVO_4$, respectively. These heterogeneous Z-scheme architectures are constructed by temperature-controlled hydrothermal synthetic methods. A relatively low-temperature

hydrothermal synthesis at 80 °C and high-temperature hydrothermal synthesis at temperatures ranging from 140 to 180 °C have been followed to tune the composition of the $BiVO_4$-based Z-scheme photocatalysts. These materials are further characterized by transmission electron microscopy, x-ray crystallographic diffraction, x-ray photoelectron spectroscopy, and UV-vis diffuse reflectance spectroscopy. Among all the nano-heterojunction materials, the $Bi_2Ru_2O_7/BiVO_4$ Z-scheme heterojunction displayed an improved photocatalytic activity in the degradation of the organic dye, rhodamine B. The $Bi_2Ru_2O_7/BiVO_4$ heterojunction degrades rhodamine B completely in 80 min compared to 300 min and 120 min for the single oxides $Bi_2Ru_2O_7$ and $BiVO_4$, respectively. The photoelectrochemical characterization indicated that the Z-scheme heterojunction improved the charge transfer and enhanced the electron/hole separation in $Bi_2Ru_2O_7/BiVO_4$ photocatalyst compared to the single catalyst. This novel bismuth vanadate/bismuth heterometal composite is a promising photocatalyst for photoelectrochemical water splitting and photodegradation of persistent organic contaminants.