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# Enhanced Photocatalytic Activity with a Heterojunction between $BiVO_4$ and BiOI

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**ABSTRACT**: One of the current key issues in the photocatalysis is to obtain the band alignment of coupled semiconductor experimentally, which is the most significant aspect for understanding the efficient photocatalytic activity precisely. In this article, a $BiVO_4$/BiOI{001} heterojunction was detected by the transmission electron microscopy (TEM). The results of electrochemical impedance spectroscopy (EIS) reveal that a higher efficiency of charge immigration across the electrode/electrolyte interface for the $BiVO_4$/BiOI{001}. In addition, the electron lifetime was investigated by the Bode phase plots, which are responsible for the observed photocatalytic behaviors. As a result, the photocatalytic activities for rhodamine B (RhB) degradation and iodine ion oxidation are remarkably increased compared to the individual $BiVO_4$ and BiOI{001}. In fact, a direct band alignment in the $BiVO_4$/BiOI{001} does not give well a logical interpreting on its photocatalytic behavior. However, through the valence-band offset formula, we demonstrated the exact band alignment of corresponding components in the $BiVO_4$/BiOI{001}. This band alignment was further confirmed by the PL spectra, which CM2 with photo-oxidation ($Mn^{2+}$) is red shift and CM2 with photo-reduction ($Ag^{+}$) is blue shift compared with CM2.

**KEYWORDS**: *Bismuth vanadate; Bismuth oxyiodide; Photocatalyst; Band alignment; Photocatalytic activity*

## INTRODUCTION

The growing environmental problems have aroused considerable attention on water cleaning and environmental remediation [1-7]. Semiconductor photocatalysis has been extensively investigated due to visible light being abundant in the solar spectrum. To be competitive in this technology, an essential element improves the separation efficiency of photo-generated electron and hole [8-12]. It is considered as a potential solution to the recent severe environmental crises [13]. Recently, tremendous work has been done on bismuth vanadate ($BiVO_4$) by various groups [14-16] due to its appropriate band gap, and favorably positioned band edges [17-19]. $BiVO_4$ has three different polymorphs, denoted as monoclinic scheelite (ms), tetragonal scheelite (ts) and tetragonal zircon (tz), among these, the ms $BiVO_4$ is found to exhibit the visible-light-driven photocatalytic activity [20-23]. It is well-known that the photocatalysis process of semiconductor photocatalysts is based on several steps: excitation, bulk diffusion, and migration of the charge carriers to the surface [24-27]. However, the $VO_4$ tetrahedrons of $BiVO_4$ are not interconnected with subsequent one, which leads to the undesirable carrier transmission characteristic [28, 29]. Thus, the photogenerated electrons and holes can easily recombine in the core or on the surface of $BiVO_4$ particles. Generally, ion doping has an obvious effect on the photocatalytic activity of $BiVO_4$ [30, 31]. However, doped materials suffer from a thermal instability; also contribute to the increase of carrier recombination centers [32]. The coupling of semiconductors (SCs) can construct a heterojunction interface between two types of SC with matching energy levels. It has been demonstrated to be an effective approach to promote charge separation in heterojunctions[33, 34], such as $BiVO_4$/$CuCr_2O_4$ [35], $Bi_2O_3$/BiOBr[36] and $BiVO_4$/$Cu_2O$/$TiO_2$ [37] etc. At the thermodynamic equilibrium state of coupled SCs, the enhanced photocatalytic activity was usually interpreted with band alignment [38-42]. In conventional synthesis methods, some inherent