Design and controllable synthesis of $\alpha$-$\gamma$-Bi$_2$O$_3$ homojunction with synergetic effect on photocatalytic activity

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HIGHLIGHTS

- Design and synthesis of $\alpha$-$\gamma$-Bi$_2$O$_3$ homojunction.
- The $\alpha$-$\gamma$-Bi$_2$O$_3$ homojunction possess the highest photocurrent and photocatalytic activities.
- The characterization of the existence of $\alpha$-$\gamma$-Bi$_2$O$_3$ homojunction.
- Synergic effect between $\alpha$-Bi$_2$O$_3$ and $\gamma$-Bi$_2$O$_3$ in the composite.

ABSTRACT

A $\alpha$-$\gamma$-Bi$_2$O$_3$ composite has been successfully prepared via a hydrothermal method. The as-prepared nanocrystals are characterized by the X-ray diffraction, Fourier transformation infrared spectrum, Scanning electron microscopy, Transmission electron microscopy, and high-resolution transmission electron microscopy examination. The homojunction between the $\alpha$-Bi$_2$O$_3$ and $\gamma$-Bi$_2$O$_3$ is confirmed by the diffuse reflectance spectra and impedance spectrum. The photocatalytic activities of the samples were evaluated by the degradation of Rhodamine B as a model pollutant. The composite exhibited higher photocatalytic activity than bare $\alpha$-Bi$_2$O$_3$ or $\gamma$-Bi$_2$O$_3$ in the degradation of RhB. The enhanced photocatalytic activity is attributed to the synergetic effect of the homojunction.

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1. Introduction

Photocatalysis has been intensively investigated as it is potential in the destruction of inorganic and organic pollutants [1–3], water splitting [4,5], and carbon dioxide photoconversion [6–8]. Since visible light accounts for larger proportion of the solar spectrum, a great number of undoped single-phase oxide semiconductor photocatalysts responding to visible light have been developed, such as BiVO$_4$ [9], CaBi$_2$O$_4$ [10], Bi$_2$MoO$_6$ [11,12], and Bi$_2$O$_3$ [13,14]. However, the photocatalytic activities of these photocatalysts are still not satisfying from the viewpoint of practical application. It is essential to design and synthesize more efficient visible-light-driven photocatalysts.

Previous studies on TiO$_2$ have shown that the photocatalytic activity of a photocatalyst is basically determined by the intrinsic properties, including crystal phase [15], defects [16], surface area [17], exposed facets [18], etc. In early 1990s, it was found the TiO$_2$ photocatalysts with mixed phases of anatase and rutile exhibited enhanced activity compared to bare one, which was attributed to the charge transfer between anatase and rutile [19]. Many investigations have been carried out on the mixed-phase of anatase and rutile [20,21]. Xu and co-workers found that mesoporous TiO$_2$ with brookite and anatase nanocrystals exhibited higher photocatalytic activity in the degradation of acetone [22]. Li demonstrated that small rutile crystallites interweaved with anatase crystallites which benefited electron transfer at the anatase/rutile interface and thus effectively created catalytic “hot spots” [23]. Generally, a material with different phases possesses different band gap and flat band. Therefore, a homojunction could be built between different crystal phase given the two phases are in close contact, which will lead to efficient electron-hole separation and higher catalytic reactivity. Although the wide band gap of TiO$_2$ determines it to be activated under ultraviolet (UV) light only, which limited its practical application, the method of constructing a homojunction is proved to be a good way to strengthen the photocatalytic activity. These findings impulse a new beginning for the design of non-titania based visible-light driven photocatalysts with mixed phase.

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