Chemical Engineering Journal 211–212 (2012) 161–167

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Design and controllable synthesis of α-/γ-Bi_2O_3 homojunction with synergetic effect on photocatalytic activity

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HIGHLIGHTS

- Design and synthesis of α-/γ-Bi_2O_3 homojunction.
- The α-/γ-Bi_2O_3 homojunction possess the highest photocurrent and photocatalytic activities.
- The characterization of the existence of α-/γ-Bi_2O_3 homojunction.
- Synergic effect between α-Bi_2O_3 and γ-Bi_2O_3 in the composite.

ARTICLE INFO

Article history:
Received 6 May 2012
Received in revised form 24 September 2012
Accepted 25 September 2012
Available online 2 October 2012

Keywords:
α-/γ-Bi_2O_3 homojunction
Synergetic
Photocatalytic

ABSTRACT

A α-/γ-Bi_2O_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 α-Bi_2O_3 and γ-Bi_2O_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 α-Bi_2O_3 or γ-Bi_2O_3 in the degradation of RhB. The enhanced photocatalytic activity is attributed to the synergetic effect of the homojunction.

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], $CaBi_2O_4$ [10], Bi_2MoO_6 [11,12], and Bi_2O_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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http://dx.doi.org/10.1016/j.cej.2012.09.084