

RHODAMINE B DEGRADATION OVER $\text{Bi}_2\text{WO}_6\text{-TiO}_2$ COUPLED PHOTOCATALYSTS UNDER SUNLIKE IRRADIATION

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Abstract

$\text{Bi}_2\text{WO}_6\text{-TiO}_2$ photocatalysts with a TiO_2 molar content of 5% was prepared by hydrothermal synthesis from a Bi_2WO_6 preparation and a titanium stock solution obtained by sol-gel method. Four different synthesis pH values were studied (pH=2, 5, 7 and 9). Synthesized samples were evaluated for rhodamine B degradation and mineralization under sunlike and visible irradiation.

Introduction

The treatment of industrial wastewaters for removing organic pollutants by advanced oxidation techniques such as heterogeneous photocatalysis is at present a very important aspect of environmental technology. In this context, TiO_2 has been as the most promising photocatalyst for the treatment of water persistent contaminants, in spite of its absorption capability limited just in the UV region. Thus new series of photocatalysts besides to TiO_2 have been studied lately in order to obtain materials with extended absorption wavelength range into the visible light region. This way, it could be exploited the sunlight irradiation. Bi_2WO_6 , between these new materials, has emerged as a promising alternative photocatalyst, since it was demonstrated that it has photocatalytic activity for O_2 evolution from a AgNO_3 solution [Kudo and Hiji, 1999] and could degrade organic compounds such as trichloromethane, acetaldehyde [Tang *et al.*, 2004] and dyes under visible light irradiation. Bi_2WO_6 nanoparticles and nanoplates prepared by different methods, including solid state reaction [Tang *et al.*, 2004], were reported initially until nanostructured Bi_2WO_6 photocatalysts with different morphologies [Zhang *et al.*, 2007; Wu *et al.*, 2007; Zhou *et al.*, 2009], and obtained by hydrothermal synthesis showed improved activities. Since then, Bi_2WO_6 superstructures have been studied, trying to control the morphology and the hierarchical structure.

In this work, we have synthesized and tested $\text{Bi}_2\text{WO}_6\text{-TiO}_2$ heterostructures (named BWT5_pH) with a low TiO_2 content, in order to enhance Bi_2WO_6 photoactivity on a dye photodegradation (rhodamine B) under not only visible light but a sunlike irradiation.

Methods

The heterostructured systems were prepared following a hydrothermal method using a TiO_2 sol as titanium source and an aqueous suspension with Bi_2WO_6 precursor. The molar ratio of TiO_2 to Bi_2WO_6 was 5 %. The resulting suspension containing both structures was transferred to a Teflon autoclave and submitted to a hydrothermal treatment. The powder obtained was further calcined. A series of catalysts were obtained at different pH values adjusted by TEA addition.

The physicochemical properties of photocatalysts were investigated by X-ray diffraction (XRD), X-ray fluorescence spectrometry (XRF), BET surface area analysis, scanning electron microscope (field emission-SEM) and UV-Vis DRS.

Photocatalytic activity was tested over a Rhodamine B (RhB) solution (10 ppm) degradation using an Osram Ultra-Vitalux lamp (300 W) with sunlike radiation spectrum. Visible photocatalytic experiments were performed by using a polyester UV filter sheet (Edmund Optics). Tests were followed by means of HPLC and a TOC analyser.

Results and discussion

In all cases, XRD patterns only showed the presence of rusellite (orthorhombic phase of Bi_2WO_6), with no apparition of TiO_2 probably due to the low $\text{TiO}_2/\text{Bi}_2\text{WO}_6$ ratio. Nevertheless, XRF results showed that Ti molar content is in good agreement with nominal value of 5%.

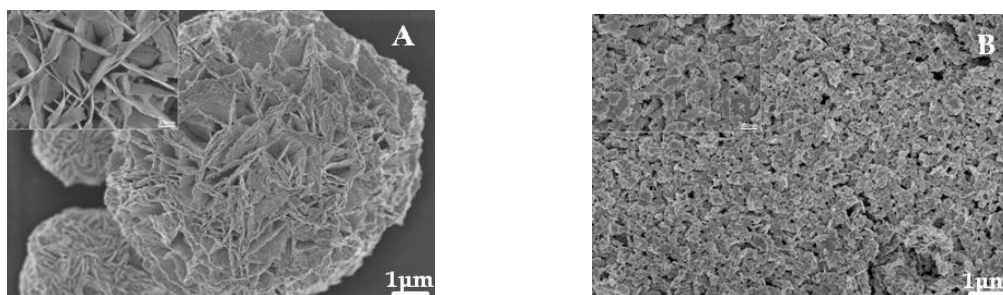


Figure 1. SEM images for (a) Bi_2WO_6 and (b) BWT5 at pH 9.

Bi_2WO_6 micrographs of SEM show that at pH 9 it is possible to obtain a superstructure by an Ostwald ripening processes as reported in literature. When adding TiO_2 , heterostructured catalyst has a plate-like morphology, even at this pH value (Fig. 1). It evidences an effect of TiO_2 incorporation. It was observed that the specific surface area (BET analysis) increased by TiO_2 incorporation, especially at acid pH. Band gap values were calculated from diffuse reflectance spectra and are close to 2.8 eV, as expected when compared to reported values for Bi_2WO_6 .

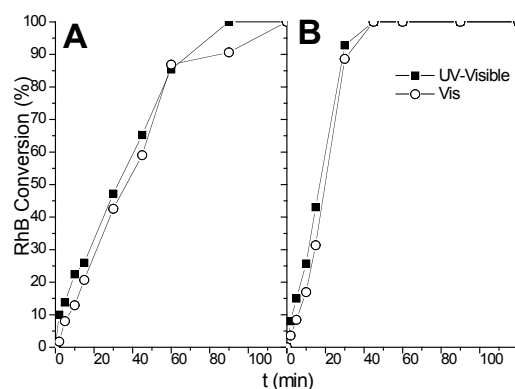


Figure 2. RhB conversions (%) for (a) Bi_2WO_6 and (b) BWT5 at pH 9.

Photocatalytic RhB degradations showed that BWT5 heterostructures have better properties under sunlike and visible irradiation. TiO_2 incorporation enhances RhB conversion. Moreover, when BWT5 is used, very similar activities are obtained under visible and UV-visible light (Fig. 2). Blank experiments showed that RhB photolysis occurs very slowly, being necessary the presence of photocatalyst in order to achieve conversion of the dye.

TOC final values are depicted in Table 1. They show that BWT5 heterostructures are able to obtain a high mineralization degree, not only the solution discoloration.

Table 1. Final TOC values (in ppm)

	UV-Visible	Visible
BW_2	1.907	3.068
BWT5_2	1.527	4.490
BW_5	3.609	5.801
BWT5_5	2.592	2.829
BW_7	3.120	4.455
BWT5_7	2.994	4.979
BW_9	2.929	2.159
BWT5_9	3.296	3.101

Conclusions

Bi_2WO_6 has demonstrated to be an efficient catalyst for dye degradation (RhB) under sunlike (and visible) irradiation, not only in a discoloration process but in achieving high mineralization degrees. Heterostructured catalysts by coupling Bi_2WO_6 and TiO_2 have improved photocatalytic activities due to efficient charges separation and a mixed excitation mechanism under UV and Visible light.

References

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