Applied Catalysis A: General 423–424 (2012) 34–41

Contents lists available at SciVerse ScienceDirect

Applied Catalysis A: General

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

# Photocatalytic activity of single and mixed nanosheet-like $Bi_2WO_6$ and $TiO_2$ for Rhodamine B degradation under sunlike and visible illumination

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ARTICLE INFO

*Article history:*
Received 14 November 2011
Received in revised form 23 January 2012
Accepted 14 February 2012
Available online 22 February 2012

*Keywords:*
Photocatalysis
$Bi_2WO_6$
$TiO_2$
Rhodamine B
Sunlike illumination

ABSTRACT

The photocatalytic activity, under sunlike illumination, for Rhodamine B (*RhB*) degradation using $Bi_2WO_6$–$TiO_2$ samples, is reported. Two different kinds of $Bi_2WO_6$–$TiO_2$ samples were studied, obtained by distinct methods: first, a mechanical mixing, by adding to synthesized nanosheet-like $Bi_2WO_6$ powder the corresponding amount of $TiO_2$ nanoparticles (P25) in order to obtain physical mixtures of both catalysts with different percentages of $TiO_2$ (5, 10 and 50 wt%); second, a single $Bi_2WO_6$–$TiO_2$ heterostructure was prepared by adding commercial $TiO_2$-P25 to the $Bi_2WO_6$ precursors (50 wt%) prior to the hydrothermal treatment, thus obtaining a sample with "in situ" $TiO_2$ incorporation. Comparisons between the photocatalytic behaviour of these samples and those exhibited by the single materials $Bi_2WO_6$ and $TiO_2$ (P25) were carried out, in order to establish the effect not only of the $TiO_2$ addition but also of the way in which $TiO_2$ (P25) is incorporated. The role of each single photocatalyst in the mixtures in the *RhB* degradation and mineralization under sunlike and just visible illumination was also studied.

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## 1. Introduction

It is widely recognized that $TiO_2$ is one of the most significant inorganic photocatalytic materials [1–3]. The relatively high quantum yield and its elevated stability are the key reasons for the preponderance of this semiconductor, which has become a virtual synonym for photocatalysts. However, it is only under the illumination of ultraviolet rays that it has high photocatalytic activity, and this fact has profoundly influenced the latter research in photocatalysis, so that modification of $TiO_2$ to achieve efficient photoactivation in the visible spectrum is an active field of research [4–11].

With the aim of obtaining enhanced photocatalytic performance, many studies on different modifications of $TiO_2$ have been performed [2,11–13]. Moreover, during the last few years an increasingly great number of new photocatalysts have been synthesized and tested as possible alternatives to $TiO_2$ to improve its spectral absorption range or the dynamic of charge carrier separation [14–16]. However, though a significant number of these new photocatalysts adequately perform under visible light, they typically display poor performance with respect to $TiO_2$ commercial references (e.g., Degussa P25) under sunlight [17,18].

In general terms, it can be said that photocatalytic activities are closely related to the structure of the photocatalysts [19–24]. This can be specially contemplated in Aurivillius based compounds, which form hierarchical structures with specific morphology and high order. These compounds have been considered concerning their role in the systematic study of structure–property relationships. In fact, several Aurivillius based compounds have been reported to exhibit interesting properties for photocatalytic applications. Among these, $Bi_2WO_6$ is the simplest member and perhaps the most studied example within this family [25–30]. Additionally, considerable effort has been taken to synthesize these hierarchical photocatalysts with small size so as to increase the separation rate of photoinduced charge carriers and consequently to achieve high activities [25]. An important point that must be stressed here is that in most cases the photocatalytic experiments reported for those systems were carried out using only visible illumination ($\lambda > 400$ nm) instead of UV–vis light. Thus, the comparison with $TiO_2$-based systems arises difficult and it is complicated to ascertain that these single phase photocatalysts are a real firm alternative to $TiO_2$ for solar applications. And thus, even though $TiO_2$ (P25) is among the most widely used materials utilized as standard photocatalyst, it suffers a practical drawback: the band-gap of 3.2 eV limits the light absorption features of this $TiO_2$ to the UV region.

In a previous paper, some of us reported the improved photocatalytic activity of $Bi_2WO_6$–$TiO_2$ heterostructures when sol–gel $TiO_2$ was prepared simultaneously with $Bi_2WO_6$ [31]. Based on a wide structural and morphological characterization, it was shown that $Bi_2WO_6$–$TiO_2$ heterostructures presented a particular

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doi:10.1016/j.apcata.2012.02.016