Journal of Photochemistry and Photobiology A: Chemistry 228 (2012) 1–7

Contents lists available at SciVerse ScienceDirect

Journal of Photochemistry and Photobiology A: Chemistry

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

Parameters controlling the photocatalytic performance of ZnO/Hombikat TiO_2 composites

Mohamed S. Hamdy [a,b], Patrick Nickels [a,b], Islam H. Abd-Elmaksood [c], Hang Zhou [a,b], E.H. El-Mossalamy [c], Abdulrahaman O. Alyoubi [c], Stephen Lynch [b], Arokia Nathan [b], Geoff Thornton [b,*]

[a] Bio Nano Consulting Ltd., 338 Euston Road, London NW1 3BT, UK
[b] London Centre of Nanotechnology, 17-19 Gordon Street, London WC1H 0AH, UK
[c] Chemistry Department, Faculty of Science, King Abdulaziz University, Jeddah 21589, Saudi Arabia

ARTICLE INFO

Article history:
Received 28 July 2011
Received in revised form 7 November 2011
Accepted 10 November 2011
Available online 20 November 2011

Keywords:
TiO_2
ZnO
Hombikat
Photodegradation
Photocatalyst

ABSTRACT

Commercial TiO_2 (Hombikat, UV-100) was impregnated with different loadings of zinc nitrate solution and subsequently calcined at different temperatures in order to obtain a stable homogeneous solid composite of ZnO/TiO_2. The prepared samples were characterized by X-ray powder diffraction (XRD), scanning electron microscopy (SEM), high resolution transmission electron microscopy (HR-TEM), UV–vis and Raman spectroscopy, inductively coupled plasma mass spectroscopy (ICP), X-ray photoelectron spectroscopy (XPS) as well as N_2 adsorption and desorption measurements. Results show that ZnO was incorporated within the TiO_2 crystals and did not form a separate bulky phase or metallic zinc. Moreover, the calcination temperature dramatically modifies the texture properties of the prepared samples compared with original Hombikat TiO_2. The photocatalytic performance of the prepared samples was evaluated by monitoring the degradation of methyl orange dye under black light illumination. Three main parameters were studied; ZnO loading, surface area and initial pH of the methyl orange solution. The variation in ZnO loading appears to have less influence on the catalytic activity than either the surface area or the pH.

1. Introduction

TiO_2 is one of the most highly performing and extensively investigated photocatalysts, utilised for the degradation of environmental contaminants [1–3]. It is reported that the photocatalytic activity of titania is highly influenced by factors including its phase structure, surface area and doping elements in its lattice. The major disadvantage of TiO_2 is its large band gap (>3 eV), which limits its photo-response to the UV part of solar spectrum (<400 nm). After years of research, the challenge still remains to improve the photocatalytic activity and efficiency of TiO_2, and to extend its photocatalytic activity into the visible part of the solar spectrum.

TiO_2 exists in three distinct crystallographic forms: anatase, rutile and brookite. It is generally accepted that anatase is more photocatalytically active than rutile [4]. The well-known Degussa P25, which contains a mixture of both phases (~75% anatase and 25% rutile) [4,5], has been shown to have higher photocatalytic activity than pure anatase [6]. One proposed mechanism explaining this enhanced efficiency is that the photo-generated electron–hole pair has a longer lifetime in this mixed phase, due to interfacial charge transfer between the two phases [2].

Recent evidence from an electron spin resonance study suggests that the photo-generated electrons are trapped in the anatase particles, while the holes are transferred from anatase to rutile [7]. Thus, the carrier recombination rate is reduced and the overall photo-generated carriers' lifetime is increased. Based on a similar charge transfer principle, the coupling of two different semiconductor oxides is suggested as an alternative way to achieve high photocatalytic activity catalyst. Recent examples can be found in a range of TiO_2 composite nanoparticles, including WO_3 [8], SnO_2 [9], Fe_2O_3 [10] and ZnO [11–14]. Of these, ZnO has been the most extensively studied metal oxide in recent years due to its exceptional electrical and optical properties [15,16]. With a band gap of 3.2 eV, ZnO has been used as a photocatalyst for water treatment. Its low cost synthesis method and its varieties of different nanomorphologies with different properties [17] have motivated this present study of the TiO_2/ZnO composite catalysts.

Previous research on the TiO_2/ZnO photocatalyst has investigated the influence of the zinc salt used to deposit ZnO, the morphology, the crystal structure and the extent of ZnO loading

* Corresponding author. Tel.: +44 020 7679 7979; fax: +44 020 7679 7463.
E-mail address: g.thornton@ucl.ac.uk (G. Thornton).

1010-6030/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.jphotochem.2011.11.001