Applied Catalysis A: General 433–434 (2012) 75–80

Contents lists available at SciVerse ScienceDirect

Applied Catalysis A: General

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

Hydrothermal crystallization of titania on silver nucleation sites for the synthesis of visible light nano-photocatalysts—Enhanced photoactivity using Rhodamine 6G

Chee Meng Ng[a], Pao-Chi Chen[b,*], Sivakumar Manickam[a,**]

[a] The University of Nottingham Malaysia Campus, Department of Chemical and Environmental Engineering, Faculty of Engineering, Jalan Broga, 43500 Semenyih, Selangor D.E., Malaysia

[b] Lunghwa University of Science and Technology, Department of Chemical and Materials Engineering, No. 300, Sec. 1, Wanshou Rd., Guishan, Taoyuan County 33306, Taiwan, ROC

ARTICLE INFO

Article history:
Received 30 March 2012
Received in revised form 4 May 2012
Accepted 7 May 2012
Available online 15 May 2012

Keywords:
Hydrothermal crystallization
Silver
Titania
Visible light
Nano
Photocatalysis
Nucleation
Rhodamine 6G

ABSTRACT

The doping of titania with metal ions is a well-established method for prolonging the recombination rate of photoexcited electrons to enhance its photocatalytic activity in the visible light region. In this work, silver–titania nanocomposite catalysts were successfully synthesized using an alternative hydrothermal synthetic pathway where suspended silver nanoparticles served as nucleation sites for the crystallization of titania. EDX analysis and TEM imaging were used to confirm the presence of silver on the titania. From the XRD results, titania produced by the present hydrothermal method were mainly in the anatase phase, while the addition of silver seemed to lower the content of rutile and brookite forms. Photocatalytic studies conducted by observing the photodegradation of Rhodamine 6G showed a marked improvement in visible light photocatalytic activity for silver-doped samples, although a diminishing effect in degradation rates was observed when silver concentration was increased beyond 3 mol%.

1. Introduction

Titanium dioxide, or titania, nanoparticles have been the subject of widespread research in photocatalytic purification, water dissociation, solar energy conversion and antimicrobial applications due to its low toxicity, photostability, and oxidation efficiency [1–5]. However, titania inherently displays weak visible light activity due to its wide band gap (~3.2 eV) and fast recombination rate of photoexcited electrons and holes. This deficiency may limit its potential real-world applications in low UV light conditions.

A common approach to increase titania's photocatalytic activity is through the doping of titania with metals such as gold, iron and silver [6–8]. The use of the latter is more common due to its relatively cheaper cost of production and inherent antimicrobial qualities which are useful in relevant applications. The mechanism behind the effect of silver doping on the enhanced visible light photoactivity has been established in the previous studies. In a nutshell, the doping of silver on the surface of titania nanoparticles prolong the recombination rate of photoexcited electrons, which leaves holes for degradation reactions of organic species to occur and increases its absorption in the visible light wavelength range [9]. These composites were proven to be effective in antimicrobial and purification applications [9–11].

Established methods of silver–titania synthesis include sol–gel reaction followed by calcination at high temperatures, photoreduction of silver on colloidal titania nanoparticles, liquid phase deposition and hydrothermal synthesis [6,7,10–16]. In this investigation, we introduce an alternative synthetic pathway for the preparation of silver–titania nanocomposites through a simple, alternative hydrothermal strategy using suspended silver nanoparticles as nucleation sites for the growth of titania crystals. The synthesis of silver–titania nanocomposites using the hydrothermal process is conducted under high pressure and through the heating of a precursor solution in a steel autoclave. The main advantages of the process are the abilities to conduct reactions at relatively lower temperatures, and, more importantly, exert more control over the final composition of the product [17]. The method had been successfully employed in other studies to produce well-crystallized metallic and polymeric nanocomposites [7,18,19].

To characterize the phase of titania, morphology, and particle size of the prepared nanocomposite, UV–vis spectroscopy, X-ray

* Corresponding author.
** Corresponding author. Tel.: +60 3 8924 8156; fax: +60 3 8924 8017.
E-mail address: Sivakumar.Manickam@nottingham.edu.my (S. Manickam).

0926-860X/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.apcata.2012.05.004