

ORIGINAL PAPER

Visible light photoelectrocatalytic degradation of rhodamine B using a dye-sensitised TiO₂ electrode

Sayekti Wahyuningsih*, Candra Purnawan, Puspa Ayu Kartikasari, Novita Praistia

Inorganic Materials Research Group, Chemistry Department, Faculty of Mathematics and Natural Science, Sebelas Maret University, Ir. Sutami Street 36A, Kentingan Surakarta 57126, Central Jawa, Indonesia

Received 13 March 2013; Revised 21 June 2013; Accepted 12 July 2013

Titanium dioxide is a promising catalyst for application in the photodegradation of organic pollutants in water due to its powerful oxidising property and long-term photostability. This study presents the production of titanium dioxide using the sol-gel process, dye sensitisation of the TiO₂ electrode, and the performance of that cell. Sensitisation of titanium dioxide was performed using a dye, i.e., Fe(II)-polypyridyl complexes. The photoelectrocatalytic degradation of rhodamine B (RB) using ITO/TiO₂/dye as electrode was investigated via a series of potentials, from +1.0 V to -1.0 V, and at various pH and NaCl concentration values (ITO is indium tin oxide conductive glass). The photoelectrocatalytic degradation of RB was performed with a visible light lamp. The change in the absorbance of RB with various potentials indicated that the absorbance of RB in solution systems with the sensitised TiO₂ electrodes decreased with increasing anodic potential bias. The degradation cell exhibited better performance when the positive anodic bias was applied. The pH values of RB in solution systems also influence the photoelectrodegradation process because of the different RB species present. NaCl concentration also affects the activity of RB photoelectrocatalytic degradation due to changes in the ionic strength character of the electrolyte.

© 2013 Institute of Chemistry, Slovak Academy of Sciences

Keywords: sensitisation, photoelectrocatalytic degradation, excitation, rhodamine B

Introduction

Interest in application of titanium dioxide in photocatalytic processes has increased significantly in recent years (Wilhelm & Stephan, 2007; Qu et al., 1998; Liu & Zhao, 2000; Hashimoto et al., 2005). The use of titanium dioxide as a photocatalyst was first reported in 1972 (Honda & Fujishima, 1972). Since then, TiO₂ nanoparticles have been used as photocatalysts in many fields as environmental applications of various pollutants (Chatterjee & Dasgupta, 2005; Chatterjee & Mahata, 2001, 2002; Wu et al., 1998). The photocatalytic activity of the TiO₂ nanoparticle under ultraviolet light is particularly prominent in the anatase form; this can be produced by the sol-gel method and sol method (Chen & Mau, 2007). The sensitised-anatase

TiO₂ has also been shown to be a good photocatalyst under visible light irradiation (Chen et al., 2010; Cho et al., 2001; Liu et al., 1999). Hence, there has been much research into the photoelectrocatalytic properties of the sensitised TiO₂ thin film to investigate its activity in the photodegradation of dye and study the related mechanism under visible radiation (Wu et al., 2000; Zainal et al., 2005; Dai et al., 2011).

The mechanism of the photo-assisted degradation of dyes under visible radiation follows a different pathway from that of UV radiation. The electrons of the dye are excited by visible light, followed by electron injection from the excited dye to the conduction band of the TiO₂ catalyst, which acts as an electron-transfer mediator. Subsequently, the cation radicals of the dye are formed and the electrons transferred to the TiO₂

*Corresponding author, e-mail: sayektiw@gmail.com