Chemical Engineering Journal 173 (2011) 178–184

Contents lists available at ScienceDirect

Chemical Engineering Journal

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

Smart chemical sensor and active photo-catalyst for environmental pollutants

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ARTICLE INFO

Article history:
Received 22 March 2011
Received in revised form 24 July 2011
Accepted 26 July 2011

Keywords:
$ZnO–CeO_2$ nanoparticles
Structural properties
Optical properties
Chemical sensing
Photocatalytic activity

ABSTRACT

In this contribution, nanoparticles composed of $ZnO–CeO_2$ were synthesized by simple and efficient low temperature process and employed for the development of effective chemical sensor as well as photo-catalyst for the removal of environmental contaminants. Field emission scanning electron microscopy (FESEM), X-ray powder diffraction (XRD), Raman spectroscopy and Fourier transform infrared spectroscopy (FTIR) were used to confirmed the morphology and structure of the synthesized $ZnO–CeO_2$ nanomaterial which revealed well crystalline aggregated nanoparticles with average diameters of $\sim 50 \pm 10$ nm. The composition of the nanoparticles was obtained by using EDS spectroscopy while the optical property was measured using UV–vis absorption spectrum. Photocatalytic degradation of acridine orange (AO) and methylene blue (MB) dyes has been carried out using $ZnO–CeO_2$ nanoparticles, which showed 92.1% degradation for AO and 80.7% degradation for MB in 170 min of irradiation time. The analytical performance of $ZnO–CeO_2$ nanoparticles fabricated ethanol sensor exhibited higher sensitivity ($2.1949\ \mu A\ cm^{-2}\ mM^{-1}$) as well as lower detection limit (0.6 ± 0.05 mM) in short response time.

1. Introduction

Rapid increase in the use of pesticides, herbicides, dyes, solvents, etc. in agricultural and large scale industrial development has been the cause of much concern for the scientific communities and regulation authorities around the world. These organic pollutants have adverse effect on the environment and are the dramatic source of aesthetic pollution, eutrophication and disturbance in aquatic life due to their toxicity and persistence. So, for environmental safeguard it is very important to detoxify these hazardous organic pollutants. Among several proposed techniques for wastewater treatment, photocatalytic oxidation process provides an alternative interesting route for the detoxification of variety of toxic and hazardous pollutants [1–5]. The mechanism of heterogeneous photocatalysis has been discussed extensively in the literature [6,7].

During the last decade, scientific communities have also showing deep research interest towards the makeup and developing chemical sensors for health monitoring and safety of the environment. So the demand to develop devices for the quantification and detection of hazardous chemicals increases day by day. Metal oxides are supposed to be a reliable candidate and has been exploited for its well-known sensing properties [8–14]. For sensing of ethanol, several metal oxides such as tin oxide, cadmium–iron oxides, cadmium–tin oxides, nickel–tin oxides have been used [15–18]. Tin oxide based sensors exhibit higher sensitivity to ethanol, but they are also sensitive to CH_4, CO and LPG. One more drawback of SnO_2 sensor operating at about 300.0 °C is that it requires long recovery time for ethanol.

The aim of the present study was to investigate very simple synthesis of $ZnO–CeO_2$ nanoparticles at low temperature and to improve the sensing and photocatalytic performance of CeO_2 by making nanocomposite with ZnO. The morphology, microstructure and optical properties of the prepared nanoparticles were characterized by XRD, FESEM, FTIR, Raman and UV/vis spectroscopy. The prepared nanoparticles were applied for the detection and quantification of ethanol using *I–V* technique. Additionally photocatalytic activity of the prepared $ZnO–CeO_2$ nanoparticles was evaluated by photodegradation of acridine orange and methylene blue. To best of our knowledge this is the first report for the quantification of ethanol using particle shape $ZnO–CeO_2$ nanocomposite employing simple and reliable *I–V* technique. These chemical sensing

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doi:10.1016/j.cej.2011.07.067