Smart chemical sensor and active photo-catalyst for environmental pollutants

M. Faisal a,*, Sher Bahadar Khan a,b,c, Mohammed M. Rahman a, Aslam Jamal a, Abdullah M. Asiri b,c, M.M. Abdullah a

a Advanced Materials and Nano-Engineering Laboratory (AMNEL) and Centre for Advanced Materials and Nano-Engineering (CAMNE), Faculty of Science and Arts, Najran University, P.O. Box 1988, Najran 11001, Saudi Arabia
b The Center of Excellence for Advanced Materials Research, King Abdulaziz University, P.O. Box 80203, Jeddah 21589, Saudi Arabia
c Chemistry Department, Faculty of Science, King Abdulaziz University, P.O. Box 80203, Jeddah 21589, Saudi Arabia

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A B S T R A C T
In this contribution, nanoparticles composed of ZnO–CeO2 were synthesized by simple and efficient low temperature process and employed for the development of effective chemical sensor as well as photocatalyst 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–CeO2 nanomaterial which revealed well crystalline aggregated nanoparticles with average diameters of ~50 ± 10 nm. The composition of the nanoparticles was obtained by using EDX 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–CeO2 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–CeO2 nanoparticles fabricated ethanol sensor exhibited higher sensitivity (2.1949 µA cm−2 mM−1) as well as lower detection limit (0.6 ± 0.05 mM) in short response time.

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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 CH4, CO and LPG. One more drawback of SnO2 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–CeO2 nanoparticles at low temperature and to improve the sensing and photocatalytic performance of CeO2 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–CeO2 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–CeO2 nanocomposite employing simple and reliable I–V technique. These chemical sensing