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Effect of Ceo_2 Doping on Photo-catalytic Performance of Hydrothermally Grown ZnO Nanocomposites

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Abstract - Pure ZnO and nanocomposites of CeO_2-ZnO have been synthesized via a simple hydrothermal method at 100^oC for 10 hr. The synthesized nanocomposites powders were study the photo-catalytic activity. The photo-catalytic activities of both nanocomposite powders have been examined by degradation of Methyl Orange (MO) using UV light. The photo-catalytic results showed that CeO_2-ZnO nanocomposites are more effective on the degradation of the MO than pure ZnO due to their soaring surface area. These results indicate that CeO_2-ZnO can be a good choice for the treatment of waste-water in by using UV-Visible light.

Keywords: ***Methyl Orange, Nanocomposite, Photo-catalytic activity, Zinc Oxide.***

I. INTRODUCTION

Organic pollutants distress the environment and human health due to their toxicity, carcinogenicity and hazardous effects [1]. Emissions of toxic elements from industrial sources were the major sources of pollution to urban wastewater. However, to reduce the levels of toxic elements emitted by industry into urban wastewater significantly. Thus the detoxification of these toxic organic pollutants from the environment has received intense research to preserve human health and environmental safety. Metal oxide semiconductor photo-catalysis is one the technique that has great potential to control aqueous organic pollutants. In a photo-catalytic system, the reaction takes place at the surface of the catalyst. The surface absorbs Ultraviolet (UV) radiation from sunlight or illuminated light source; it will produce pairs of electrons and holes. The positive-hole of breaks apart the water molecule to form hydrogen gas and hydroxyl radical. This cycle continues when light is available. the holes move in the opposite direction from the electrons, Probably hole can react with pollutant water molecule and abstract the electron from pollutante molecule and process of degradation takes place.[2,3], therefore significant efforts have been trialed out to improve photo-catalysis performance which includes addition of catalyst, addition of metals or metal oxides as dopants, which decrease the grain size, controlling the surface-to-volume ratio, to improve photo-catalysis properties of the material [4]. Such systems are useful for promoting the separation of electron hole pairs [5]. In addition surface area and surface defects plays an important role in the photo-catalytic activities of metal oxide nanostructures; the ideal candidates for application of photo-catalysis since they offer a soaring surface area.

In the present study, we have synthesized pure ZnO and CeO_2-ZnO nanocomposites via a simple hydrothermal method. Effects of CeO_2 addition on structural, morphological and photo-catalysis properties of ZnO based photo-catalytic activities are reported herein.

II. EXPERIMENTAL

2.1. Preparation of Pure ZnO and ZnO-CeO_2 nanocomposites

Pure ZnO and ZnO-CeO_2 nanocomposites were synthesized using hydrothermal process in which zinc acetate dihydrate (Zn $(CH_3COO)_2 \cdot 2H_2O$) and cerium nitrate hexahydrate (Ce $(NO_3)_3 \cdot 6H_2O$) were dissolved in distilled water (180 mL) with a constant stirring for about 30 min at room temperature and then the pH value was adjusted to 10 by drop wise addition of NaOH solution. The hydrolysis process was carried out at 100°C for 10hr in a Teflon-lined stainless autoclave. After terminating the reaction, white precipitate was obtained that was washed with water and ethanol for several times and dried at room temperature..Methyl Orange (MO) was used as a model dye to evaluate the photo-catalytic activity of the pure ZnO and CeO_2-ZnO nanocomposites.

2.2. Characterization

The photo-catalytic activity of the two samples was characterized by measuring the degradation efficiency of MO by using of the powder (0.2 g) which was ultrasonically dispersed in 100 mL of MO solution. The mixture was stirred for 30 min to keep the suspension homogenous and then was placed under UV lamp (365 nm). About 5 mL of the solution was taken after different time intervals (0, 30, 60, and 90 min) and measured the dye concentration. Degradation effieciency of dye was determined by the UV-Vis–NIR spectrophotometer.

III. RESULTS AND DISCUSSION

3.1. Results of Characterization

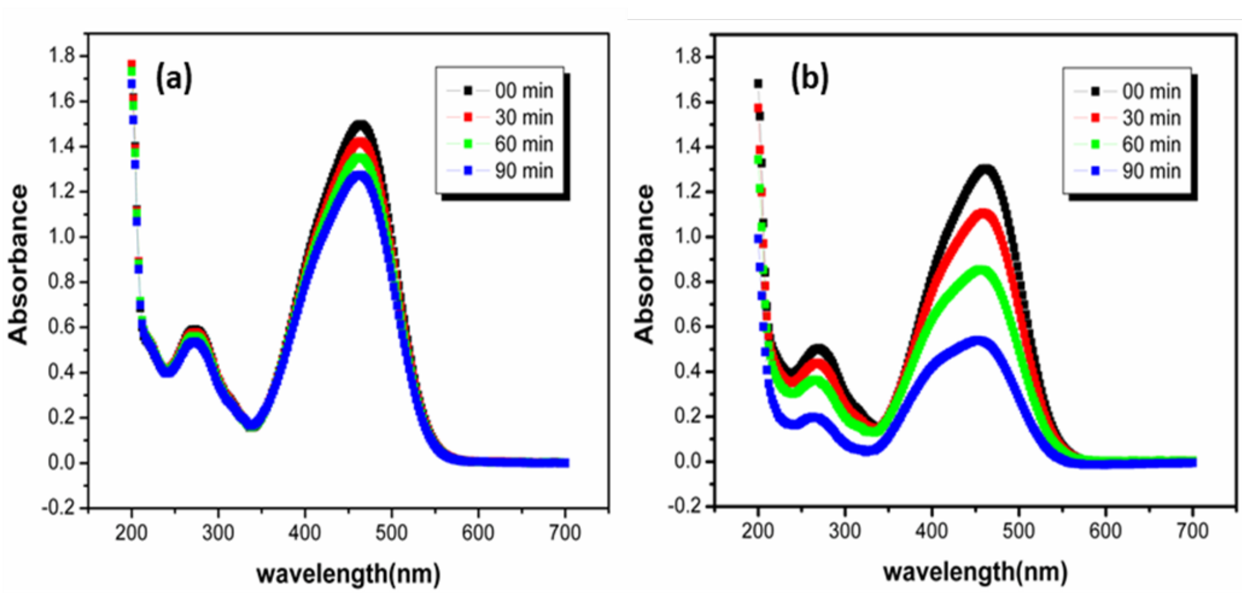

Figure 2. UV–Vis absorption spectra of MO on (a)ZnO and (b)CeO_2-ZnO

Figure 2 shows the optical absorption spectra of the methyl orange solution at different time intervals of the photo-degradation reactions over pure ZnO and CeO_2-ZnO. Figure 2(a) shows the maximum photo-degradation response of 1.29 at 90 min, while other shows photo-degradation response 1.50, 1.44, 1.38 at 00, 30, 60 min respectively. Figure 2(b) shows the maximum photo-degradation response of 0.56 at 90 min, while other shows photo-degradation response 1.31, 1.12, 0.86 at 00, 30, 60 min respectively. For both samples, the degradation behavior was found to be similar but with different time responses. The CeO_2-ZnO shows maximum absorbance at 460 nm and photo-degradation response towards methyl orange solution.

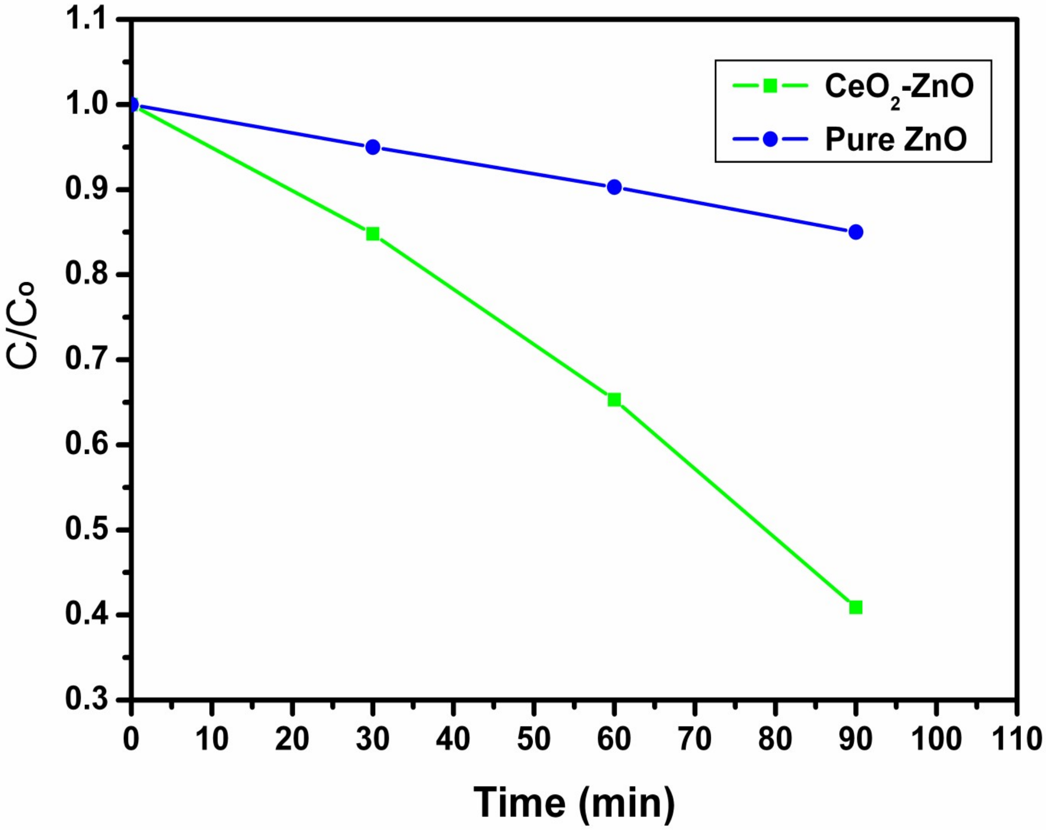

Figure 3. Graph time Vs C/C_0 of pure ZnO and CeO_2-ZnO

Figure 3 shows that the graph of time Vs. C/C_0. The photo-degradation results of pure ZnO and CeO_2-ZnO. In which C_0 and C are the initial concentration after the equilibrium adsorption and the reaction concentration of MO, respectively. It has been observed that synthesized pure ZnO and CeO_2-ZnO nanostructures show different photo-catalytic activities towards MO dye. It is well-known that photo-catalytic activity is a surface phenomenon and is mainly controlled by density of the reactive species [6-8]. Doping with metals oxide such as CeO_2 gives rise reactive species densities and surface states causing enhancement in the photo-catalytic activities [9]. Normally, for higher specific surface area and higher quantity of reactive species, photo-catalytic activities of the material is higher [10] .The large surface area could provide more active sites for reactant molecules and promote the efficiency of the electron-hole separation [11].Meanwhile, higher photo-catalytic activity of the CeO_2-ZnO is considered to be due to the higher surface area than that of the pure ZnO.

IV. CONCLUSION

Pure ZnO and CeO_2-ZnO nanaocomposite were synthesis using a hydrothermal method and photo-degradation tested for the methyl orange dye under UV irradiation at room temperature. The photo-catalytic activity results showed that the CeO_2-ZnO nanocomposites are more effective on the degradation of MO, which was attributed to the changes in surface area, crystal size values of the material, therefore it is concluded that these degradation properties of CeO_2–ZnO nanostructures can be a good choice for the treatment of waste-water.

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