Photocatalytic Degradation Of An Azo Dye With ZnO Nanoparticles

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Abstract: In the present paper we reported the method to prepare ZnO nanoparticles by alkaline precipitation method for the degradation of an azo dye. We have used ZnO nanoparticles assisted with UV light irradiation to investigate the photocatalytic degradation of azo dyes. The ZnO photocatalyst was characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and photoluminescence.

Keywords: Photocatalytic degradation, ZnO nanoparticles, Azo dye, XRD.
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INTRODUCTION

Azo dyes are the most commonly used commercial dyes in the textile industry, accounting for over 50% of all commercial dyes. a large amount of azo dyes, however, remain in the factory effluent after the completion of the dyeing process and represent an environmental danger due to their refractory nature. this organic compound contains azo groups (N=N) mainly bound to substituted benzene or naphthalene rings [1]. Many efforts have been devoted to develop technologies that are able to minimize the hazardous effects caused by industrial activities. among many options, the development of processes to transform the toxic and hazardous pollutants into harmless compounds, is one of the most effective solutions [2]. Photocatalytic degradation of organic pollutants in water using semiconductive particles, such as tio$_2$and zno, has attracted extensive attention. ZnO is a suitable alternative to TiO_2 as it has a similar band gap energy (3.2 ev), larger quantum efficiency than tio$_2$and higher photocatalytic efficiencies have been reported. ZnO is a low cost alternative photocatalyst to TiO_2 for decolorization of organic compoundss in aqueous solutions [3]. Here we are interested in the photocatalytic decolorization of azo dye contaminants by the zinc oxide photocatalyst. the zno photocatalyst was synthesized and the photocatalytic decolorization of azo dye was carried out over the photocatalyst under irradiation. in this work, zinc oxide nanoparticles have been prepared via alkaline precipitation method. degradation of an azo dye was used as a probe reaction to evaluate the photocatalytic activities of ZnO nanoparticles in uv light irradiation.

EXPERIMENTAL DETAILS

Synthesis of ZnO NPs

To prepare of ZnO NPs, in a typical experiment, a 0.45 M aqueous solution of zinc acetate and 0.9 M aqueous solution of sodium hydroxide (NaOH) were prepared in distilled water. Then, the beaker containing NaOH solution was heated at the temperature of about 55 ºC. The $(CH_3COO)_2Zn$ solution was added dropwise (slowly for 30 min) to the above heated solution under high speed stirring. The beaker was sealed at this condition for 2 h. The precipitated ZnO NPs was cleaned with deionized water and ethanol then dried in air atmosphere at about 60 ºC. Morphology of the sample was investigated using Jeol scanning electron microscope.

. The structural characterization of ZnO nanoparticles was performed by Bruker D8 Advanced X-ray diffractometer. The photoluminescence studies were done by Shimadzu spectrofluorophotometer. Degradation of dye solutions was monitored by a Double beam UV-visible spectrophotometer (Varian Cary 50 Bio). Concentration was measured by spectrophotometer at λmax of 530 nm. In all experiments, doubly distilled water was used throughout this study and the initial pH of solutions was adjusted as appropriate by addition of either HCl or NaOH. The results of blank experiments under

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similar conditions but without the addition of catalysts indicated that there was a negligible loss of solution volume due to the UV irradiation and reactor open to the air and also the loss of substrate was negligible.

RESULTS AND DISCUSSION

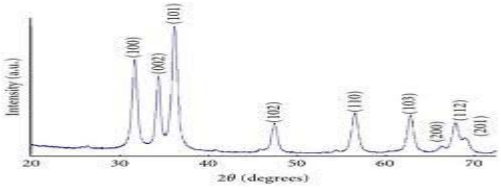

FIGURE 1. XRD spectra of ZnO nanoparticles.

Fig.1 shows the XRD pattern of ZnO nanoparticles. The diffraction pattern and interplanar spacing closely match those in the standard diffraction pattern of wurtzite (or hexagonal) ZnO. Furthermore, there was no distinct peaks observed which indicate the high purity of the naonoparticles.

In Fig.2, SEM image of ZnO nanoparticles showed that most of the nanoparticles are spherical almost and fairly monodispersed. On the other hand, the mean diameter of ZnO estimated from the SEM image is 65 nm.

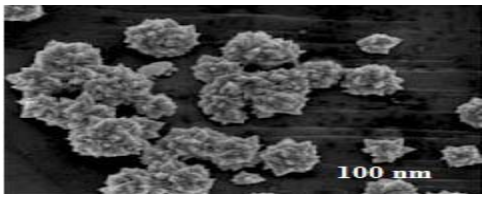

FIGURE 2. SEM image of ZnO nanoparticles.

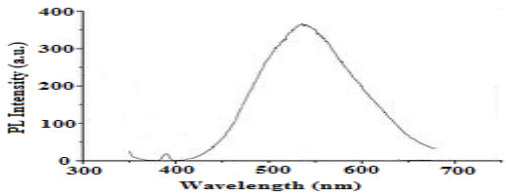

FIGURE 3. PL spectra of ZnO nanoparticles.

Fig. 3 shows the PL spectrum of ZnO nanoparticles with an excitation wavelength of 345 nm. A broad stronger emission band in the green part of the visible spectrum with the maximum intensity observed at 548 nm (band gap energy 2.4eV). The origin of the broad green emission band at 2.4 eV is attributed to surface anion vacancies.

Photodegradation of azo dye by zinc oxide

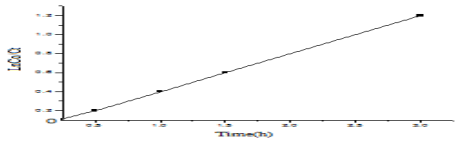

FIGURE 4 Effect of UV-irradiation time on the degradation of azo dyes at initial concentration 5 mg/L in de-ionized water using zinc oxide nanoparticles.

Fig. 4 shows curve between the $\ln(C_0/C)$ versus time, where C_0 and C were the concentrations of the primal and remaining azo dye, respectively. Curve shown in Fig. 4 was linear, revealing that the kinetic data of the azo dye photocatalytic decolorization fit well to the first-order reaction. Assuming first-order reaction kinetics for the photocatalytic oxidation process, the decolorization rate constant was determined from the equation $\ln(C_0/C_t)=-kt$, where C_0 and C_t are the dye concentrations at times 0 and t , respectively, and k is the first-order rate constant.

Photodegradation experiments were carried out at dye concentration 5 to 20 mg/L, reaction temperature 30°C zinc oxide nanoparticles. The rate of photocatalytic degradation of zinc oxide nanoparticals catalystsis higher compared to pure ZnO . The self-degradation of azo dye without involving photocatalysts was negligible under UV light irradiation .

CONCLUSION

The zinc oxide nanoparticles can be prepared by alkaline precipitation method. The particles was characterized by XRD, SEM and PL. The zinc oxide particles has been employed in photocatalytic oxidation of azo dye. It can be conclude that the ZnO nanoparticles are promising and efficient catalyst to degrade organic pollutants and create pollution free environment.

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