



Synthesis, Characterization and Photocatalytic Activity of ZnO Nano Powder on the Degradation of Azo Dye Acid Orange 8

H. C. Basavaraju^{1*}, J. P. Shubha²

¹Department of Chemistry, Jnanavikas Institute of Technology, Bidadi - 562 109, Karnataka, India. ²Department of Chemistry, Don Bosco Institute of Technology, Bengaluru – 560 074, Karnataka, India.

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ABSTRACT

ZnO nanopowder with crystallite size in the range 55-97 nm was prepared by combustion technique and was characterized by powder X-ray diffraction, scanning electron microscope, and Fourier transform infrared spectroscopy. Photocatalytic degradation of acid orange 8 (AO8) dye was carried out with ZnO nanopowder. The effect of amount of ZnO, concentration of the dye, pH and irradiation time on photocatalytic degradation of AO8 is studied. The results reveal that the maximum decolorization (more than 70%) of dye occurred with ZnO catalyst in 35 min of stirring at alkaline pH.

Key words: ZnO, Photocatalysis, Azo dye degradation, Acid orange 8.

1. INTRODUCTION

A variety of dyes used in textile industry usually have a synthetic origin and multifaceted aromatic molecular structures which make them more stable and more complicated to be biodegraded [1-3]. Colored industrial effluent is the most apparent indicator of water pollution, and the discharge of highly colored synthetic dye effluents is aesthetically displeasing and cause considerable damage to the aquatic life. The effluents are strongly colored which not only created environmental and aesthetic problems but also posed a great potential toxic threat to ecological human health as most of these dyes are toxic and carcinogenic. Predominantly azo dyes which contain one or more nitrogen to nitrogen double bonds (-N=N-) constitutes a significant portion that is widely used in industries today. The strong electron-withdrawing character of the azo group stabilizes these aromatic pollutants against conversions by oxygenases. Therefore, azo dyes are not readily degraded under aerobic conditions. Hence, removal of azo dye effluents generated by food and dye industries is a main issue in wastewater treatment. These effluents are commonly treated using physicochemical methods such as adsorption, photodegradation [4-7], and coagulation. All of these processes are expensive and complicated. Therefore, there is a need for economical and simple methods to abolish harmful dyes in effluents [1,8]. Dyes can be degraded in the presence of photocatalyst on irradiation with visible light because of their absorption in the

visible region [9]. Photo-assisted degradation of some dyes have been investigated [10-12].

Acid orange 8 (AO8) is one of the important monoazo dyes and possesses a simple structure. It is used in the form of its salts in dyeing, as an intermediate in the manufacture of acid yellow, diazo dyes, and indulines [1]. Thus, keeping the hazardous nature and harmful effects in view, it was considered worthwhile to make systematic efforts to degrade AO8 from aqueous medium using low-cost ZnO nanopowder.

In the light of these considerations, we report herein, the hitherto unreported results on the photocatalytic degradation of AO8 under solar irradiation were studied. The aim of this work is to study the effect of (i) catalyst concentration, (ii) dye concentration, and (iii) pH of the dye solution on the degradation of the dye.

2. EXPERIMENTAL

Zinc nitrate ($Zn(NO_3)_2 \cdot 4H_2O$) (Merck) and AO8 (SRL) and were used as received. Commercial sugar ($C_{12}H_{22}O_{11}$) was used as fuel. Double distilled water was used in this work.

2.1. Techniques

The powder X-ray diffraction patterns of ZnO samples were obtained using a Philips PW/1050/70/76 X-ray diffractometer using Cu K α radiation at a scan rate of

*Corresponding Author:
E-mail: mmhills_basav@yahoo.co.in

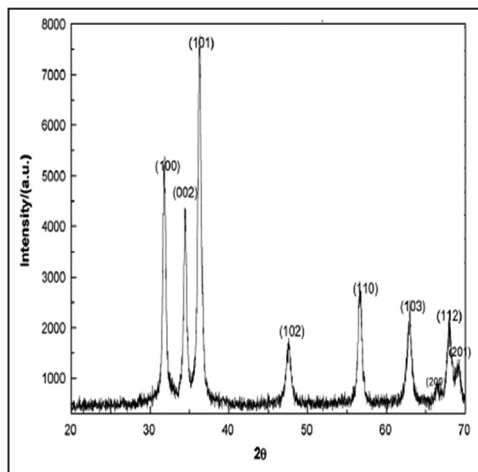


Figure 1: Powder X-ray diffraction of ZnO.

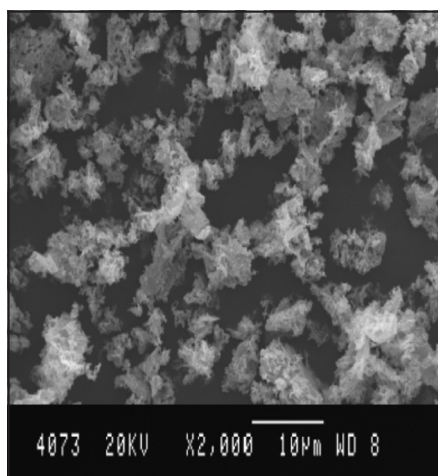


Figure 2: Scanning electron microscope images of ZnO sample calcined at 500°C.

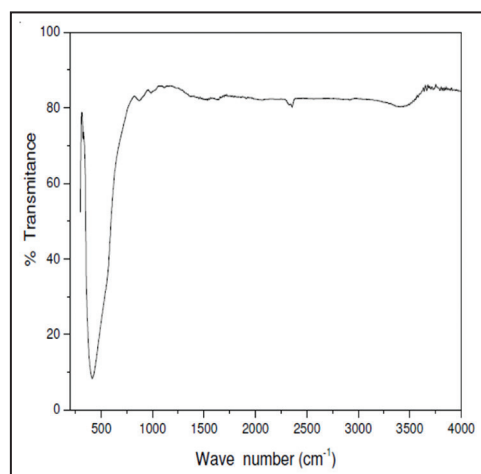


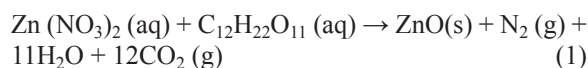
Figure 3: Fourier transform infrared spectrum of as-formed ZnO nano powder.

2°/min (Figure 1). The morphology of powders was examined using JEOL (JSM-840A) scanning electron microscopy (Figure 2). Fourier transform infrared (FTIR) spectra were recorded using Nicollet IMPACT

400 D FTIR spectrometer, in the range 400-4000 cm^{-1} as KBr pellet. The absorption spectra were recorded with a UV-visible spectrophotometer (Elico SL-159) (Figure 3).

2.2. Preparation of Catalyst ZnO Nano Powder

Zinc nitrate (5.0 g) and sugar (1.2 g) taken in a cylindrical pyrex dish of 300 mL capacity were dissolved in a minimum quantity of double distilled water and dispersed well using a magnetic stirrer for 0.5 h. The resulting homogeneous redox mixture was rapidly heated in a muffle furnace maintained at $300 \pm 10^\circ\text{C}$. The redox mixture boils, froths, and dehydrates forming a honey like gel which burns with an incandescent flame. The product of combustion is voluminous, fluffy, and porous. The gaseous products formed such as oxides of nitrogen by the thermal decomposition of metal nitrates at $300 \pm 10^\circ\text{C}$ are hypergolic. The whole process takes place in <5 min. The reaction may be represented as follows:



3. RESULTS AND DISCUSSION

3.1. Photocatalytic Activity of ZnO Nano Powder

To estimate the photocatalytic activity of ZnO, degradation of AO8 was undertaken. A typical experiment constitutes 100 ml of 10 ppm dye solution and 0.2 g of catalyst taken in a glass reactor. The mixture was stirred for 30 min to establish the adsorption equilibrium between the dye molecules and the catalyst surface. The solution was irradiated with solar light.

Experiments were carried out during the summer season between 11.30 am to 2.30 pm during which fluctuation in the solar intensity is minimum. The decolourization efficiency (%) was calculated as follows:

$$\% \text{Degradation} = \frac{C_0 - C}{C_0} \times 100 \quad (2)$$

Where, C_0 is the initial concentration of dye and C is the concentration of dye after photoirradiation. Similar experiments were carried out by varying the pH of the solution, concentration of dye and catalyst (Figures 4 and 5).

4. CONCLUSIONS

Nano ZnO powder has been synthesized by a simple, quick and novel low-temperature solution combustion method and was employed as a catalyst for the degradation of AO8 dye. It was found that the dye is completely decomposed on irradiation in the presence of the ZnO catalyst at alkaline pH under solar light irradiation in about 35 min stirring time. The complete

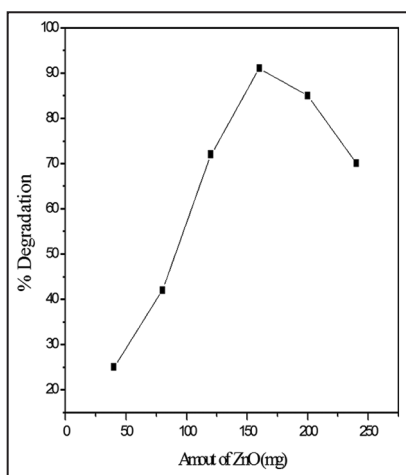


Figure 4: Plot of degradation of acid orange 8 against amount of ZnO.

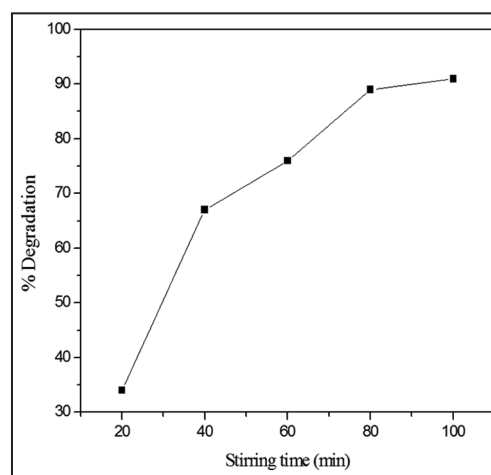


Figure 7: Plot of degradation of acid orange 8 against stirring time at pH 10.

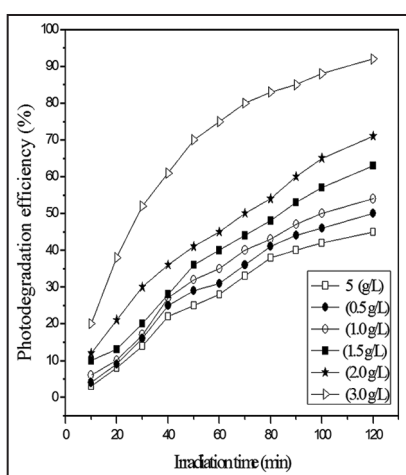


Figure 5: Plot of degradation of acid orange 8 against different dye concentration.

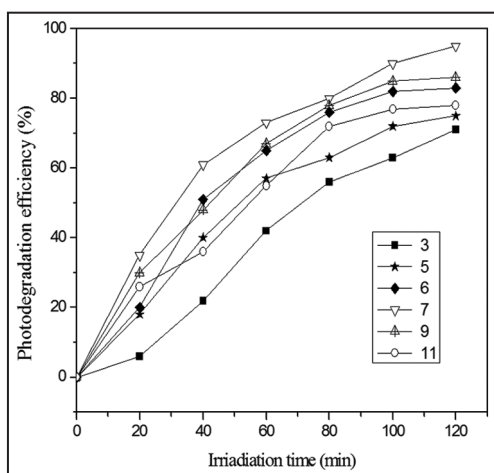


Figure 6: Plot of degradation of acid orange 8 against pH.

decolorization of the dye was followed by UV-Visible spectrophotometry.

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***Bibliographical Sketch**



Dr. H. C. Basavaraju is presently working as Professor and Head Department of Chemistry in Jnanavikas Institute of Technology, Bidadi, Bangalore-Mysure Highway road. He is having 19 years of Teaching experience and 4 years of Research experience. He has published 13 papers in national and international publications & presented 4 papers in national and international conferences. Also attended workshops based on faculty development, personality development and skill based.