INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE & TECHNOLOGY
© VISHWASHANTI MULTIPURPOSE SOCIETY (Global Peace Multipurpose Society) R. No. MH-659/13(N)
www.vmsindia.org

ZnO Nanostructures: Useful Photo-Catalytic Material

Rahul R. Kurzekar[1]; Pralhad K. Rahangdale[2]*and Hemant M. Pande[3]

[1]Chotabhai Jawerbhai Patel College, Tirora-441911, India
[2]Bhawabhuti Mahavidyalaya. Amgaon-441902, India
[3]Hislop College Nagpur-440001, India
*Corresponding *Author,Email: pralhadrahangdale@gmail.com*

Abstract
ZnO nanostructures were synthesized by simple and efficient low temperature method. The structure and morphology of the ZnO nanostructures was characterized by X-ray powder diffraction (XRD) and scanning electron microscopy (SEM), which revealed wurtzite hexagonal phase ZnO nanostructures with diameters of 50–200 nm. Photo-catalytic activity of ZnO nanostructure was evaluated by degradation of congo red which degraded 96.75% in 220 min in vis-spectrum. These degradation properties of ZnO nanostructures are of great importance for the application of ZnO system as an useful photo-catalystic material

Key words: ZnO, nanostructures; photocatalytic activity; congo red dye, vis-region.

Introduction

Organic compounds such as dyes, pesticides, herbicides, phenols and various solvents are widely used in industries and daily life, and are the main contaminants and effluents discharged by the industries. These organic pollutants distress the environment and human health due to their toxicity, carcinogenicity and hazardous effect [1–6]. Thus the detoxification of these toxic organic compounds from the environment has received intense research to preserve human health and environmental safety.

Many traditional techniques such as flocculation, precipitation, adsorption on granular activated carbon, air stripping or reverse osmosis, chemical oxidation, and biological methods have been used so far for the treatment of organic waste effluents, but they lose their importance due to some limitations and disadvantages such as high cost, ineffectiveness and inefficiency and cannot destroy the organic dye molecules but just transfer the organic pollutions from one phase to another,i.e.from water to another phase[3–8]. Therefore, there is an urgent demand for efficient and profitable method to eliminate these organic contaminants from the environment. Photo-catalysis as a method of treatment of wastewater in the presence of metal oxides is an exciting option for the detoxification of organic pollutants, whose mechanism has been broadly studied[1–10].

Acceleration in nanoscience and nano technology and the extension of new nanostructure material, nano-sensors, and micro-devices have been played a major role in the development of very accurate, sensitive, and reliable sensors. Metal oxides are the model materials for sensing owing to high surface areas and are widely used as sensor for the detection of various hazardous gases as well as chemicals or biochemicals [11,12]. Thus ZnO nanostructures have been proposed as redox mediator and photocatalyst to detect and detoxify the organic pollutants.

The aim of the present study is to develop a photocatalyst for the degradation of organic pollutants. Therefore, well crystalline ZnO nanostructures were simply synthesized by low-temperature procedure and characterized by X-ray powder diffraction (XRD), scanning electron microscopy (SEM). Photocatalytic activity was evaluated by photodegradation of congo red.

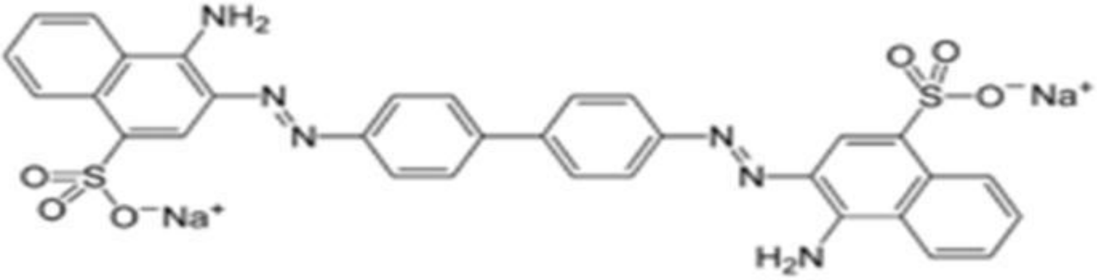

Fig 1: Chemical structure of congo red (CR)dye

Experimental

Materials

All the chemicals were purchased from MERK and used without further purification. Distilled water was used throughout the study.

Synthesis of ZnO nanostructures (NPs) [13]

ZnO NPs were synthesized by magnetic stirrer method in which $ZnCl_2$ (4.0 g) was dissolved in distilled water (300 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 NH_4OH solution. The resultant solution was then stirred at 80°C for 6 h. After terminating the reaction, white precipitate was obtained which was washed with water and ethanol several times and dried at room temperature. The resulting white powder was calcined at 400°C for 5 h.

Characterization

The morphology of the nanomaterial was studied by XRD and SEM spectra

Photo-catalytic experiments

ZnO nanostructures were applied for the photocatalytic decomposition of congo red (25ppm), and their performance was evaluated by using optical absorption spectroscopy. The photo-catalytic decomposition reactions were performed in a 250 ml beaker. 150 ml of dye solution was added to the beaker and 150 mg of catalyst (ZnO nanorods) was added into the dye solution and then stirred for 15 min. The suspension was endlessly bubbled with air and irradiated with 500 W visible lamp. 5.0 ml of samples were collected at regular intervals and dye solutions were separated from the photocatalyst by centrifugation before analysis. The degradation was monitored by measuring the absorbance on UV-visible spectrophotometer. The absorbance of congo red (25ppm) was followed at 520 nm wavelength, respectively.

Results and Discussion

scanning electron microscopy

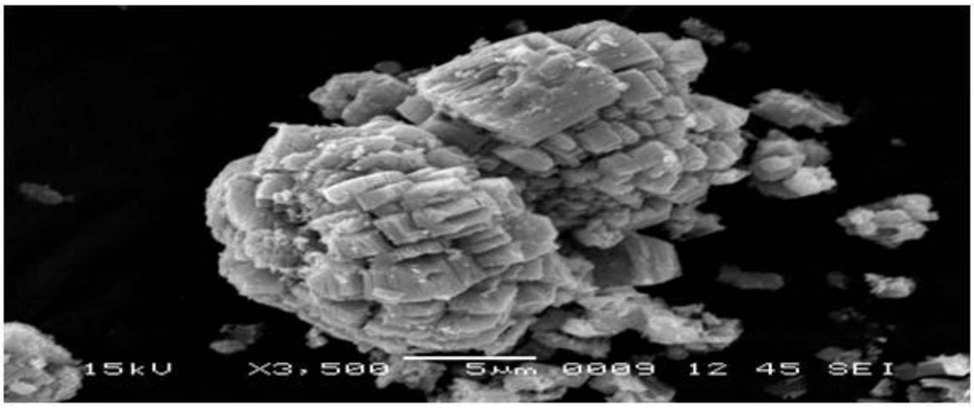

Fig. 2: SEM image of ZnO Nps

Morphology and size of the nanomaterial were investigated by SEM which is shown in Fig.2. According to the low and high magnification of SEM images, the synthesized products are elongated nanostructures possessing unsmooth surface (Fig.1). The average diameter and length of the grown nanostructures are determined in the rangeof 50-200 nm, respectively. These unsmooth surface and elongated nanostructures suggest that the nanomaterial is of ZnO nanostructures .

X-ray diffraction

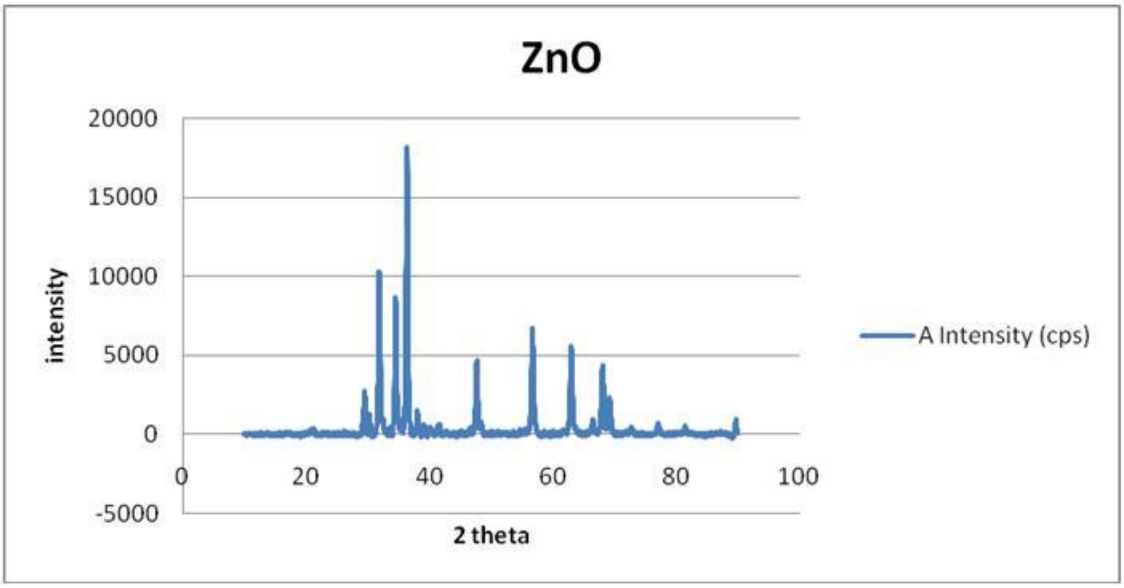

Fig. 3: XRD pattern of the synthesized ZnO nanostructures

Crystal structure and crystallinity of the ZnO nanostructures were analysed by XRD which is represented in Fig. 3. The strong diffraction peaks of ZnO are detected in the sample at angle 31.77,34.42, 36.35, 47.53, 56.60, 62.86, those marked with could be indexed to (111), (200), (220), (311), (222), (400), (331), (420), and (422) phases, which demonstrate that the synthesized product have well-crystalline[18]. Besides, the feature peak marked with are indexed to wurtzite hexagonal phase ZnO[19]. All the characteristic peaks observed are well-matched with those of wurtzite hexagonal well-crystalline ZnO. XRD thus confirms that the obtained nanomaterial is the ZnO.

Photo-catalytic property

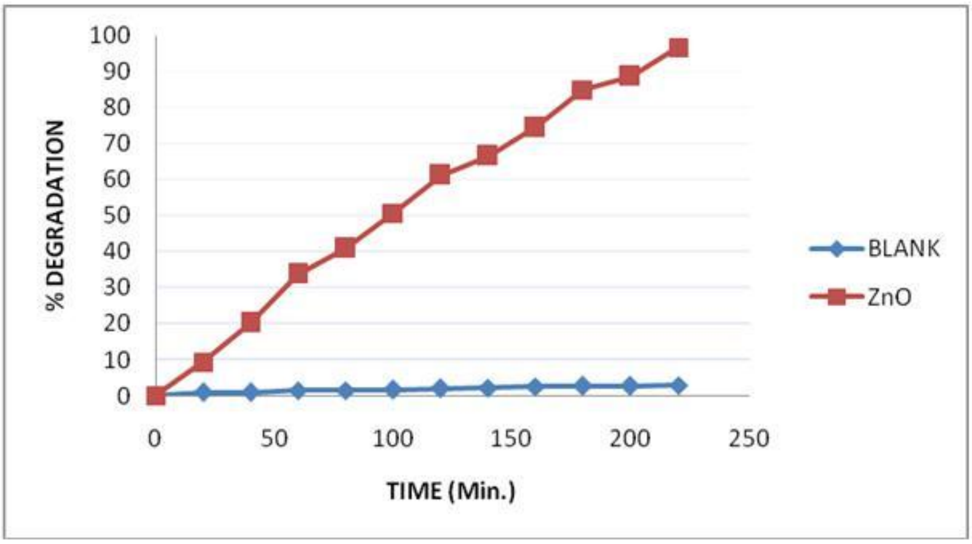

Fig.4: Plot for degradation of CR dye by ZnO Nps.

Figure 4 shows a plot for the degradation percent vs irradiation time (min) for the oxygen saturated aqueous suspension of CR in the presence and absence of the synthesized nanostructures.

It can be seen that 96.75% of acridine orange was degraded by ZnO NpS and Blank (in the absence of ZnO nanostructures) CR 2.99% are degraded for 220 min of irradiation time whereas in the absence of nanomaterial, no observable loss of dye can be seen.Thus the above results clearly indicate that ZnO nanostructures have very simple synthesis procedure and show considerable photocatalytic activity for the dye under consideration. So it can also be a beneficial photocatalyst besides other metal oxides.

Conclusions

- ✓ Preparation of ZnO nanostructures by magnetic stirring method at low temperature is succesefull.
- ✓ The aphotocatalytic material under investigation have been proved to posses well crystalline, wurtzite hexagonal structure which is suported by Sem and XRD studies
- ✓ The photocatalytic performances of ZnO nanostructures has been proved to be excellent for degradation of ongo red dye.

Acknowledgement

Authors are thankful to the Principal, Hislop college, Nagpur for providing laboratory and Other necessary facilities. Thanks are also due to the Director, IIT, BHU for XRD and SEM scaning.

REFERENCES

[1] M. Faisal, M.A. Tariq and M. Muneer: Dyes Pigment., 2007, 72, 233.

[2]M. M. Rahman, A. Jamal, S.B. Khan and M. Faisal: J. Nanopart.Res.,2011,11,301

[3] D. Ravelli, D. Dondi, M. Fagnoni and A. Albini: Chem. Soc. Rev., 2009, 38, 1999.

[4] S. Malato, P. Fernandez-Ibanez, M.I. Maldonado, J. Blanco and W. Gernjak: Catal. Today, 2009, 147, 1.

[5] L.Y. Yang, S.Y. Dong, J.H. Sun, J.L. Feng, Q.H. Wu and S.P. Sun: J. Hazardous Mater., 2010, 179, 438.

[6] X.C. Song, Y.F. Zheng, E. Yang, G. Liu, Y. Zhang, H.F. Chen and Y.Y. Zhang:J. Hazardous Mater.,2010, 179, 1122.

[7] S. Anandan, A. Vinu, N. Venkatachalam, B. Arabindoo and V. Murugesan: J. Molecular Catalysis A:Chemical, 2006, 256, 312.

[8] J.H. Sun, S.Y. Dong, Y.K. Wang and S.P. Sun: J. Hazardous Mater., 2009, 172, 1520.

[9] R. Qiu, D. Zhang, Y. Mo, L. Song, E. Brewer, X. Huang and Y. Xiong:J. Hazardous Mater., 2008, 156,80.

[10] R.Y. Hong, J.H. Li, L.L. Chen, D.Q. Liu, H.Z. Li, Y.Zheng and J. Ding: Powder Technol., 2009, 189, 426.

[11] S.G. Ansari, Z.A. Ansari, H.K. Seo, G.S. Kim, Y.S. Kim, G. Khang and H.S. Shin: Sens. Actuator. B,2008, 132, 265.

[12] M.M. Rahman, A. Umar and K. Sawada:Sens. Actuator. B, 2009, 137, 327.

[13] M. Faisal, Sher Bahadar Khany, Mohammed M. Rahman, Aslam Jamal, Kalsoom Akhtar and M.M. Abdullah J. Mater. Sci. Technol., 2011, 27(7), 594-600.

[14] F. Niu, D. Zhang, L. Shi, X. He, H. Li, H. Mai and T.Yan: Mater. Lett., 2009, 63, 2132.

[15] F. Xu, G.H. Du, M. Halasa and B.L. Su:Chem. Phys.Lett., 2006, 426, 129.

❖❖❖❖