© 2016 IJSRSET | Volume 2 | Issue 2 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Synthesis of ZnO nanorods by Novel Surfactant Assisted Wet Chemical Method and It's Photocatalytic Activity

V. Shally, M. Priya Dharshini, P. Libin Raj, Sr. Gerardin Jayam

Research Department of Physics, Holy Cross College, Nagercoil, Tamil Nadu, India

ABSTRACT

In this paper, synthesis of ZnO nanorods is done by a simple and surfactant assisted wet chemical method. The obtained ZnO nanorods can be characterized using various techniques like Powder X-ray Diffraction (PXRD), Field Emission Scanning Electron Microscopy (FESEM) and UV-DRS Spectroscopy. XRD results reveal that the sample is crystalline with a hexagonal wurtzite phase with the particle sizes of 30 nm. Field Emission Scanning Electron Microscopy (FESEM) result reveals that the ZnO nanoparticles are rod like shaped. The band gap of ZnO nanorods was determined from Tauc Plot. The photocatalytic activity of ZnO nanorods has been examined by the degradation of Congo Red dye using UV light.

Keywords: Nanorods, Congo Red, Photocatalytic activity, Tauc plot, Band gap

I. INTRODUCTION

Nanosized particles of semiconductor materials have gained much more interest in recent years due to their desirable properties and applications in different areas such as catalysts [1], sensors [2], photoelectron devices [3, 4], highly functional and effective devices [5]. Among all the semiconductor nanomaterial, ZnO nanomaterial such as nanorods, nanotubes and nanowires have been intensively chosen due to their remarkable properties such as wide direct-band gap (3.37 eV) at room temperature and a large exciton - binding energy (60 meV) [6] which allows UV lasing action to occur even at room temperature [7]. Due to its unique optical and electrical properties [8], it is regarded as a potential material in optoelectronic applications operating in the visible and near ultraviolet spectral regions. It has been used considerably for its catalytic, electrical, opto electronic and photochemical properties [9-12].

ZnO nanostructures have a great advantage to apply to a catalytic reaction process due to their large surface area and high catalytic activity [13]. Zinc oxide nanoparticles (ZnO-NPs) with the features of large surface to volume ratio and high UV absorption have been widely used in many industrial areas such as solar cells [14], in optoelectronic devices [15] such as light-emitting diodes, photodetectors and p- n homojunctions. Gas sensors [16, 17], photo catalysts [18], pharmaceutical and cosmetic industries [19]. Moreover, ZnO is bio-safe and biocompatible and can be used for biomedical applications without coating. With these unique characteristics, ZnO could be one of the most important nanomaterial in future research and applications [20].

II. METHODS AND MATERIAL

The ZnO nanoparticles can be prepared using zinc nitrate hexahydrate ($Zn(NO_3)_2 \cdot 6H_2O$), sodium hydroxide (NaOH) as precursors and CTAB as surfactant are prepared by simple wet chemical method. The advantage of wet chemical method is the non-requirement of calcination temperature.

1M Zinc Nitrate was dissolved in distilled water and the solution was kept under constant stirring at room temperature using magnetic stirrer for one hour. Zinc Nitrate solution was added drop wise in this CTAB

solution. 2 M of sodium hydroxide solution was dissolved and heated up to 60 ^{0} C. After completely dissolving the solution of zinc nitrate and CTAB, this solution is added drop wise to the beaker containing the hot NaOH solution and immediately white precipitate of ZnO nanoparticles are formed. Washing was carried out to remove the unwanted byproducts and the excessive CTAB that were bound with the nanoparticles. After washing, the nanoparticles were dried at 60° C for overnight. During drying, complete conversion of Zn (OH) ^{2} into ZnO take place.

III. RESULTS AND DISCUSSION

Structural Characterization

Powder X-ray Diffraction (PXRD) analysis was used to determine the phase of pure ZnO nanoparticles. The powdered samples were characterized by powder X-ray diffract meter XPERT PRO with Cukα X ray radiation (λ=0.15496 nm). All the diffraction peaks for pure ZnO match well with the wurtzite structure of hexagonal phase with the **JCPDS Card No: 89-0510** and lattice constants **a = 3.248 Å, c = 5.2051 Å and cell volume V= 47.60 (Å) ^{3}.** No other extra peaks except ZnO are found which reveals the good crystalline nature of the samples. The broadening of the peaks in the above XRD pattern can be attributed to the small particle size of the synthesized ZnO.

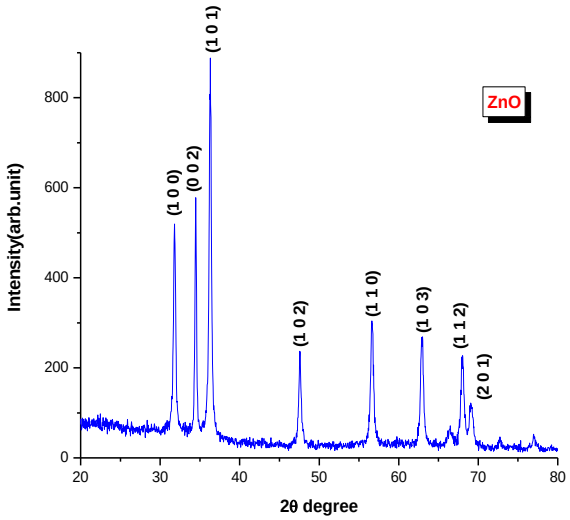


Figure 1 : Indexed PXRD pattern of Pure ZnO nanoparticles

For ZnO nanoparticles, the intensity of the peak corresponding to (1 0 0) plane should be greater than that of (0 0 2) plane [8]. But here, the intensity of the peak corresponding to (0 0 2) plane is greater than that of (1 0 0) plane, which indicates the different tropism (rod formation) of the samples. The crystallite size of pure ZnO is calculated from Scherer's equation and is found to be 30.01 nm.

Morphological studies and Elemental Analysis

The surface morphology of the samples is observed by Field Emission Scanning Electron Microscopy (FESEM).

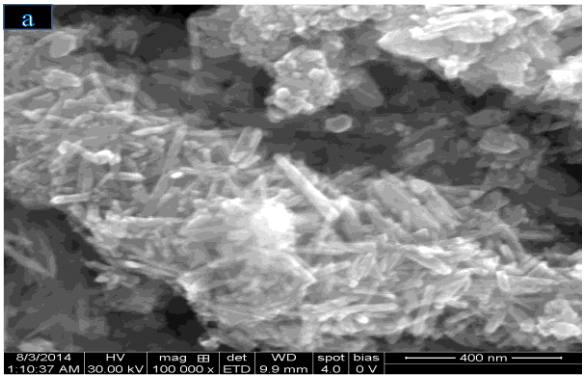


Figure 2 : *FESEM images of pure ZnO nanoparticles*

Typical FESEM images of the ZnO nanostructures for 400 nm magnification shows that the synthesized ZnO nanoparticles are rod like clusters which are formed in a large-scale area and the results indicate that the as prepared ZnO nanorods are uniform with diameters of 125 nm and length of about 26 nm.

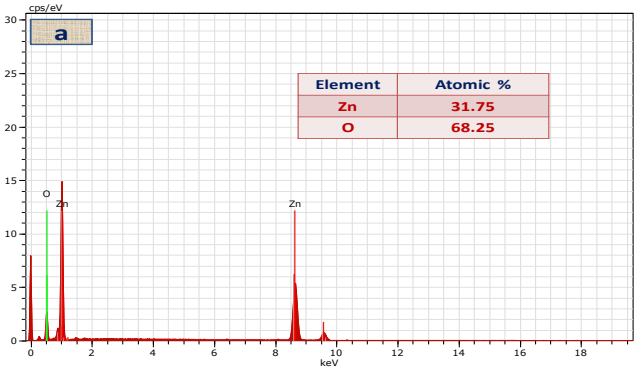


Figure 3 : *EDX spectra of pure ZnO nanoparticles*

The chemical analysis of the pure ZnO nanorods measured by EDX analysis shows that only Zn and O signals have been detected, No signal of secondary phase or impurity was detected, thus suggested the high purity of ZnO nanorods.

Optical Studies

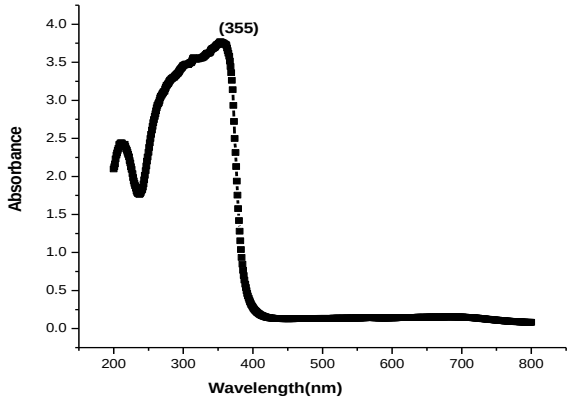


Figure 4 : UV-DRS spectrum of pure ZnO nanoparticles

The exciton absorbance of pure ZnO is about 355 nm. The optical band gap E_g of the Nano crystals is calculated from Tauc plot. The band gap value of ZnO nanoparticles is found to be 3.26 eV. The band gap energy of the samples are measured by the extrapolation of the linear portion of the graph between the modified Kubelka-Munk function $[F(R) h\nu]^2$ versus photon energy ($h\nu$) [5]. The band gap estimated for this sample (3.26 eV) is slightly lower than that of bulk ZnO (3.37eV).

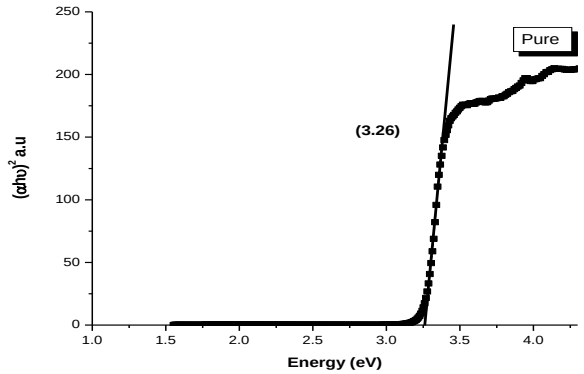
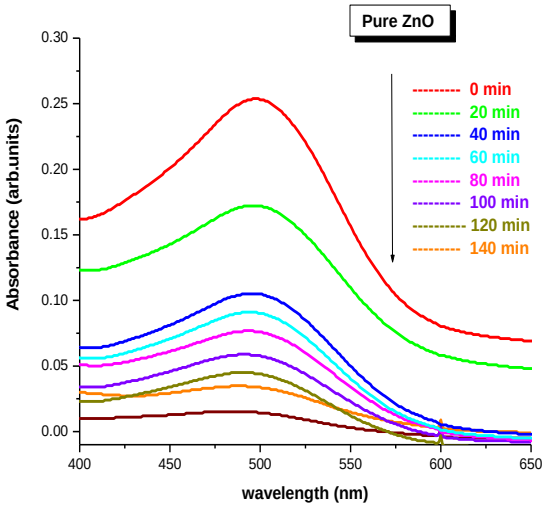


Figure 5 : *Tauc Plot of of pure ZnO nanoparticles*

Photocatalytic Studies



The maximum degradation time for pure ZnO is 140 min and the degradation efficiency is 90 %. From the photo catalysis results, it was observed that the photo degradation of congo red dye occurs through an oxidative pathway by photo generated holes, leading to an irreversible permanent mineralization process.

IV. CONCLUSION

A good catalyst should be stable under operation conditions. Therefore, the chemical stability of the ZnO photo catalyst was assessed. The photo catalytic activity results showed that the nanorods are more effective on the degradation of congo red dye, which was attributed to their high surface area making them promising candidates for the treatment of organic waste-water.

V. REFERENCES

[1] Surabhi Siva Kumar, Putcha Venkateswarlu Vanka Ranga Rao and Gollapalli Nageswara Rao, International NanoLetters,Vol.3:30, PP.1-6, (2013).

[2] X.L. Cheng, H. Zhao, L.H. Huo, S. Gao, J.G. Zhao, Sensors and Actuators B: chemical, Vol. 102, Issue 2, Pages 248- 252, (2004).

[3] S. Y. Lee, E. S. Shim, H. S. Kang, S. S. Pang, Thin Solid Films, Vol. 437, No. 1, PP. 31-34, (2005).

[4] Zhong Lin Wang, ,Xiang Yang Kong ,Yong Ding, Puxian Gao ,William L. Hughes , Rusen Yang and Yue Zhang , Advanced Functional Materials, Vol.14,No.10,PP. 943–956, (2004).

[5] Huang YH, Zang Y, Liu L, Fan SS, Wei Y, He J, Journal of Nanoscience and Naotechnology,Vol.6(3),PP.787–790,(2006).
[6] Michael H. Huang, Samuel Mao, Henning Feick, Haoquan Yan, Yiying Wu, Hannes Kind, Eicke Weber, Richard Russo, Peidong Yang, Science, Vol. 292, PP.1897–1899, (2001).
[7] Lionel Vayssieres, Karin Keis, Anders Hagfeldt, and Sten-Eric Lindquist, Chemistry of Materials, Vol. 13 (12), PP. 4395–4398, (2001).
[8] R. Konenkamp, L. Dloczik, K. Ernst, and C. Olesch , Physica E: Low-Dimensional Systems and Nanostructures, Vol. 14, No. 1-2, PP. 219–223, (2002).
[9] D. Brida, E. Fortunato , H. Aguas, V. Silva, A. Marques, L. Pereira, I. Ferreira, R. Martins, Journal of Non-Crystalline Solids ,Vol .299–302,PP. 1272–1276, (2002).
[10] Zhong Lin Wang, Journal of Physics: Condensed Matter, Vol. 16, PP. R.829 R858, (2004).
[11] M.Suchea,S. Christoulakis , K. Moschovis, N. Katsarakis and G. Kiriakidis , Thin Solid Films, Vol. 515, PP. 551–554, (2006)
[12] A.Ashour, M.A. Kaid, N.Z. El-Sayed, A. A Ibrahim, Applied Surface Science, Vol.252, PP.7844–7848, (2006).
[13] Jyh-Cherg Chen ,Chun-Tien Tang, Journal of Hazardous Materials, Vol.142, Issues 1-2 , PP. 88-96 , (2007).
[14] W. J. E. Beek, M. M. Wienk, and R. A. J. Janssen, AdvancedMaterials,Vol.16, No.12, PP. 1009–1013, (2004).
[15] Morales A.M and Libber C.M, Science, Vol. 279, PP. 208, (1998).
[16] Eric R Waclawik, Jin Chang, Andrea Ponzoni, Isabella Concina, Dario Zappa, Elisabetta Comini, Nunzio Motta, Guido Faglia, Giorgio berveglieri, Beilstein Journal of Nanotechnology, Vol. 3, No. 1, PP. 368–377, (2012).
[17] Prabhakar Rai and Yeon- Tae Yu, Sensors and Actuators B: Chemical, Vol.173, PP.58-65, (2012).
[18] Ziwei Deng , Min Chen, Guangxin Gu and Limin Wu, Journal of Physical Chemistry B, Vol. 112, No. 1, PP. 16–22, (2008).
[19] J. W. Rasmussen, E. Martinez, P. Louka, and D. G. Wingett, Expert Opinion on Drug Delivery,Vol. 7, No. 9, PP. 1063–1077, (2010).
[20] Zhong Lin Wang, Nanostructures of zinc oxide, Materials Today, PP. 26-33, (2004).