Synthesis of Copper Oxide Nanoparticles Using Simple Chemical Route

Jyoti Mayekar, Vijay Dhar, S. Radha

Abstract—Metal and metal oxide particles are intensively pursued because of their prominence in different fields of applications in Science and Technology. In this paper, copper oxide nanoparticles are synthesized by wet chemical precipitation method and are characterized by using XRD (X ray diffraction), SEM (Scanning Electron Microscopy) and EDAX (Energy Dispersive X ray Spectroscopy) . XRD data reveals that copper oxide was formed as CuO and it has monoclinic structure.The particle size of the nanoparticles formed have sheet like structures with approximately 20-30 nm width and 100-200 nm length.This method is convenient, easy and effective in comparison to the known methods of synthesis of nanomaterials like thermal decomposition of precursors, co- implantation of metal and oxygen ions and ultrasonic spray pyrolysis.

Index Terms- Copper oxide nanoparticles, nanotechnology, Scanning Electron Microscopy, Magnetic study, XRD, EDAX, Nanomaterials

1 INTRODUCTION

Transition metals are large in number and have number of applications in different field of applications. CuO is one of the useful metal oxide and which has many applications in different fields. Copper oxide nanoparticles are of special interest because of their efficiency as nanofluids in heat transfer applications. It has been reported that 4% addition of CuO improves the thermal conductivity of water by 20% [1]. CuO is a semiconducting compound with a narrow band gap and used for photoconductive and photothermal applications[2].

CuO-NPs have been prepared with different sizes and shapes *via* several methods such as sonochemical [3], direct thermal decomposition [4], electrochemical methods [5], colloid-thermal synthesis process [6], and microwave radiation [7].

In the present manuscript, we have synthesized CuO nanoparticles by simple aqueous precipitation method. This method involves a simple, cheap and one step process for synthesis of CuO nanoparticles. The synthesized nanoparticles were characterized by XRD, EDAX and SEM.

The unique property of CuO is it acts as a semiconductor. Semiconductor materials have been particularly interesting because of their great practical importance in electronic and optoelectronic devices, such as electro chemical cell [8], gas sensors[9] , magnetic storage devices [10], Nano fluid [11], and catalysts [12] etc.

The favorable band gap of CuO (1.0 eV to 2.08 eV) makes it useful for solar energy conversion and it can be used for solar cell window preparation.

In the synthesis of metal oxide nanoparticles, polymers are used to stabilize the aggregation of metal atoms. Polyvinylpyrrolidone (PVP) is the most commonly used polymer in the preparation of metal oxides because of its distinct shape, dissolved metal salts, and transport facility. PVP consists of repeating chains of polar groups, which help dissolve metal salts and facilitate transport. Without PVP, the metal nanoparticle is unstable. This instability causes rapid destruction of the membrane [13].

2 EXPERIMENTAL

For synthesis of copper oxide nanoparticles, 2.9 gms of copper nitrate is mixed with 1.2 gms of polyvinylpyrrolidone (PVP) and 100 ml of distilled water. Stir this solution using magnetic stirrer and heat the solution till it reaches 60^0C. Take 1M of sodium hydroxide solution. Once the desired temperature is reached, add sodium hydroxide solution to above solution drop by drop. Heat and stir for one hour. Black precipitate will be formed. Centrifuge it and oven dry at 50^0C for two hours to get copper oxide nanopowder.

$Cu(NO_3)_2 + 2NaOH \rightarrow Cu(OH)_2 + 2NaNO_3$

$Cu(OH)2 \rightarrow CuO + H_2O$

The pH of the solution plays an important role in the synthesis of copper oxide nanoparticles. For 0.2M, 0.4M, 0.6M, O.8M concentration of sodium hydroxide blue solution is obtained and the pH is of the order of 4-8 but for 1 M solution of soc
for
sol

3

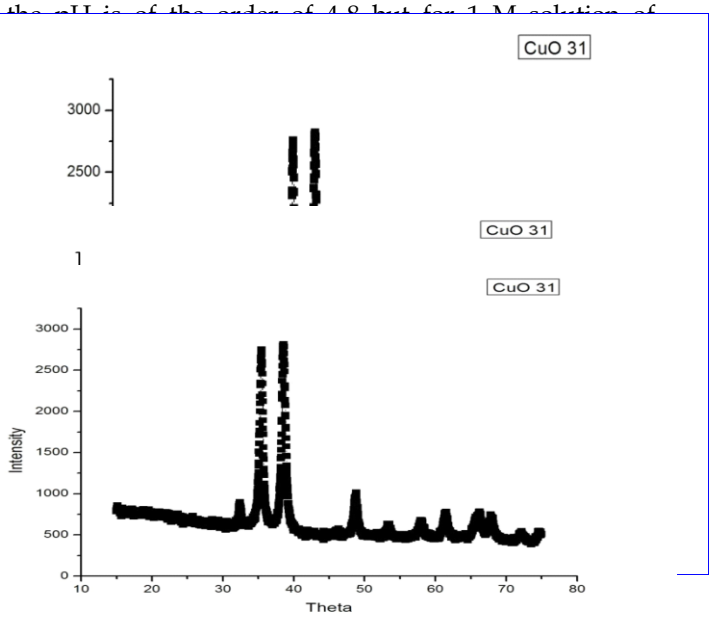

Figure 1 XRD spectra of copper oxide nanoparticles

Fig. 1 shows the XRD pattern of prepared CuO Nano particles. All the peaks in diffraction pattern shows monoclinic structure of copper oxide nanoparticles. The peaks are compared with JCPDS card no.[89-5895] and miller indices are identified. The lattice parameters were calculated from XRD data using the formula

$$\frac{1}{d^2} = \left(\frac{4}{3}\right)\left(\frac{h^2 + hk + k^2}{a^2}\right) + \frac{l^2}{c^2}$$

Lattice parameters are a = 4.84 Å, b = 3.47 Å, c = 5.33 Å.
The average grain size calculated by using Debye -Scherrer formula is approximately 52.09nm.
Formula for the calculation of grain size

$$D = \frac{0.9}{\beta \cos\theta}$$

Where β is full width half maxima of the peak in XRD pattern
θ is peak obtained angle.
λ is X- ray wavelength.

3.2 Energy Dispersive X ray Spectroscopy

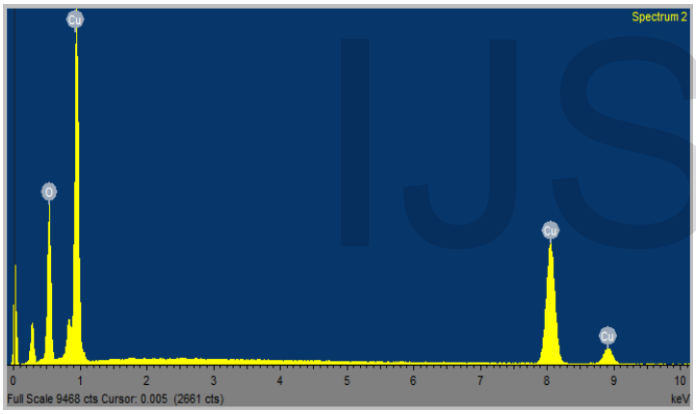

Fig. 2: Energy Dispesive X ray spectra of copper oxide nanoparticles

Fig. 2 shows Energy Dispersive X-Ray Analysis of copper oxide nano particles and the data indicates the nano powders are nearly stoichiometric. There are no traces of other impurities like carbon etc. in the EDAX spectra. The EDAX result confirms the formation of pure CuO nano particles.

Table 1: Elemental composition of Cu and O in Copper oxide nanoparticles using EDAX analysis

Spectrum	O	Cu
Spectrum 1	59.27	40.73
Spectrum 2	61.23	38.77
Mean	60.25	39.75

3.3 Scanning Electron Microscopy

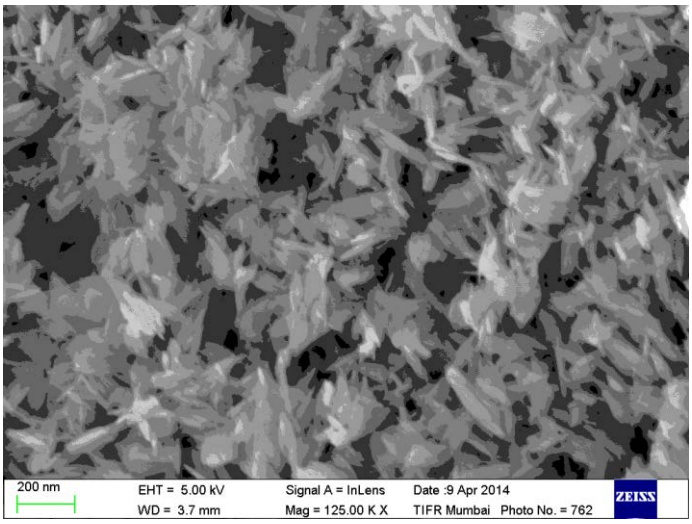

Fig. 3 Scanning electron Micrograph of zinc oxide nanoparticles

The actual size of nano particles is estimated from SEM micrograph. Most of the nanoparticles have size around less than 50 nm and which is in correlation with the particle size analyser data. The SEM graph also shows that the copper oxide nanoparticles are sheetlike or rodlike in shape.

4 Conclusion

A very versatile, non toxic and environmental friendly approach for the synthesis CuO nanoparticles is presented in this paper. XRD pattern revealed copper oxide nano particles have monoclinic structure. From EDAX analysis the copper oxide nano particles are pure and free from impurities.. SEM photograph shows good agglomeration of CuO nano particles. This facile, reproducible and low cost approach should promise us a future large scale synthesis of nanostructures for many applications in nanotechnology.

Acknowledgment

One of the authour (J. Mayekar) is pleased to acknowledge Tata Institute of Fundamental Research, Mumbai for characterization of samples and Bhavan's College, Mumbai for the synthesis facilities made available.

References

[1] S. Lee, U. S. Choi, S. Li and J. A. Eastman, Measuring Thermal Conductivity of Fluids Containing Oxide Nanoparticles, J. Heat Transfer, 121, 280 (1999).

[2] K. Borgohain, J. B. Singh, M. V. Rama Rao, T. Shripathi and S. Mahamuni, Quantum Size Effects in CuO Nanoparticles, Phys. Rev., **61**, 11093 (2000).

[3] A. Sambandam, G-J. Lee, J. Wu Sonochemical synthesis, *Ultrason. Sonochem. Sonochemical synthesis of CuO nanostructures with different morphology* 19 (2012) 682-686

[4] E. Darezereshki, F. Bakhtiari, A novel technique to synthesis of tenorite(CuO) nanoparticles from low concentration CuSO4 solution*J. Min. Metal., Sect. B.*, 47 (2011) 73.

[5] G. Yuan, H. Jiang, C. Lin, S. Liao, shape controlled electrochemical synthesis of cupric oxide nanocrystals, *J. Cyst. Growth.* 303 (2007) 400.

[6] Y. Lim, J. Choi, T. Hanrath,Facile synthesis of colloidal CuO nanocrystals for light harvesting applications *J. Nanomaterials,* 2012 (2012) 4.

[7] H. Wang, J. Xu, J. Zhu, , H. Chen,Preparation of CuO nanoparticles by microwave irradiation *J. Cryst. Growth,* 244 (2002) 88.

[8] P. Poizot, S. Laruelle, S.Grugeon, L.Dupontl, J.M. Tarascon, Nano-sized transition - metal oxides as negative-electrode materials for lithium-ion batteries, Nature 407, 496 (2000).

[9] V.R. Katti, A.K. Debnath, K.P. Muthe, M. Kaur, A.K. Dusa, S.C. Gadkari, Mechanism of drifts in H2S sensing properties of SnO2:CuO composite thin film sensors prepared by thermal evaporation, Sens actuators B chem , 245 (2003)

[10] H.M. Fan,L.T. Yang, W.S. Hua, X.F. Wu, Z.Y. Wu S.S. Xie, Controlled synthesis of monodispersed copper oxide nanocrystals, Nano technology. 15, 37 (2004).

[11] M.H. Chang, H.S.Liu, C.T. Tai, Preparation of copper oxide nanoparticles and its application in nanofluid, Powder technology 207,378-386 (2011).

[12] C.L. Carnes, K.J. Kalbunde., The catalytic methanol synthesis over nanoparticle metal oxide catalysts J. Mol. Catal. A Chem 194,227-236 (2003).

[13] Jose, B.; Ryu, J. H.; Kim, Y. J.; Kim, H.; Kang, Y. S.; Lee, S. D.; Kim, H. S., Effect of plasticizers on the formation of silver nanoparticles in polymer electrolyte membranes for olefin/paraffin separation. *Chem. Mater.* **2002,** *14* (5), 2134-2139.