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Short Communication

Synthesis and Optical Absorption Properties of Copper Oxide Nanoparticles for Applications in Transparent Surface Coatings and Solar Cells

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A simple wet chemical method has been successfully deployed to synthesize CuO nanoparticles (NPs) by using copper chloride and lithium hydroxide as the precursors. X-ray diffraction study revealed that the synthesized CuO is highly crystalline and pure. The synthesized CuO NPs has very high transparency in the visible region of wavelength. The band gap of the CuO NPs was found to be 1.54 eV.

Keywords: CuO, Chemical-synthesis, TEM, Absorption, Band-gap.

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1. INTRODUCTION

Researches on low dimensional materials, popularly known as the nanomaterials, has drawn considerable attention to the scientists and engineers due to their versatile properties developed in the nanoscale regime. In low dimension, the carriers in the crystal are bound within very small region. This is known as quantum confinement. Thus the density of states for carriers becomes different from the bulky materials structure. Copper oxide (CuO) is a very well-known semiconductor being investigated now a day due to its multifunctional properties. It has excellent catalytic property. It can modify the several chemical and physical properties during a chemical reaction [1]. It is a direct band gap semiconductor of band gap energy about 1.2 eV [2]. However, this band gap may be enhanced in the nanoscale regime due to the quantum confinement effect.It has very high thermal and electronic conductivity, chemical stability. Thus it is found to be very effective materials for several device applications like in solar cells, ion batteries wide [3-4]. CuO exhibit light absorption property in a wider range of electromagnetic spectrum. Researchers have also reported the anti-bacterial activity exhibited by CuO nanoparticles [5]. Here in this paper we report a simple wet chemical synthesis of CuO nanoparticles followed by typical structural and morphological characterization. Optical absorption property of the synthesized CuO has been analysed to investigate the underlying photo absorption mechanism.

2. MATERIALS AND METHOD

In brief, predetermined amount of copper chloride was dissolved in deionised water to prepare 0.2 M copper chloride solution. It was added drop wise with 1 M LiOH solution under vigorous stirring. The stirring was continued further for 2 hrs at room temperature. At the end of the reaction, a brownie white precipitate was deposited at the bottom of the flask. The precipitate was filtered and washed with deionized water for the removal of any unreacted salts. It was then dried in a furnace at 200 °C for further characterizations.

The morphology of the prepared materials was observed in JEOL transmission electron microscope (TEM) operating at 5 kV. UV-visible (UV-VIS) absorption data were recorded in a Perkin Elmer LS45 spectrophotometer in the wavelength range from 200 nm to 1200 nm.

3. RESULTS AND DISCUSSIONS

Typical TEM image of the synthesized material is shown in Fig. 1.

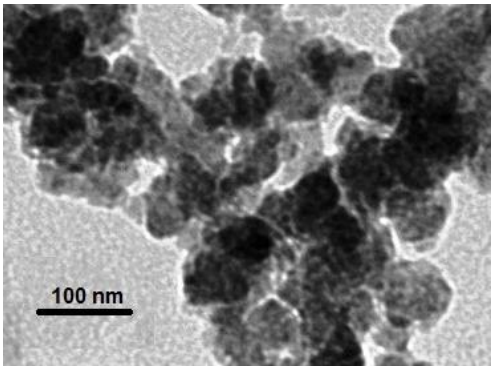

Fig. 1 – TEM image of CuO nanoparticles dispersed on carbon coated copper grid

Well grown nanoparticles are found to form with size 80 nm. The sizes of the nanoparticles are not uniform. This indicates the bottom up growth of the nanoparticles.

The basic chemical reactions involved are as follows:

$$CuCl_2 + LiOH \rightarrow Cu(OH)_2 + LiCl$$
$$Cu(OH)_2 + 2H_2O \rightarrow Cu^{2+} + 2OH^- + 2H_2O$$
$$Cu^{2+} + 2OH^- + 2H_2O \rightarrow Cu(OH)_4^{2-} + 2H^+$$
$$Cu(OH)_4^{2-} \rightarrow CuO + H_2O + 2OH^-$$

In reaction between $CuCl_2$ and LiOH in aquatic media, $Cu(OH)_2$ is formed initially which further produces $Cu(OH)_4^{2-}$. At the onset of saturation CuO nuclei are formed and grow up to form the nanoparticles. The basic form of $Cu(OH)_2$ and CuO are shown in Fig. 2 and Fig. 3 respectively.

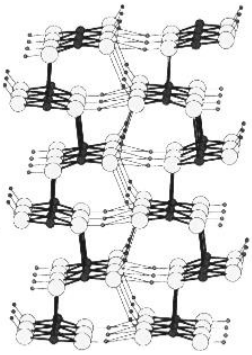

Fig. 2 – Crystal structure of $Cu(OH)_2$

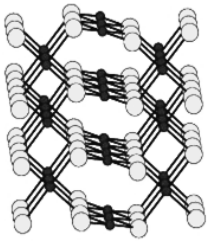

Fig. 3 – Crystal structure of copper oxide

Optical absorption property of a material can be investigated from the UV-visible absorption spectroscopy. Typical UV-visible absorption spectrum of synthesized CuO nanoparticles is shown in Fig. 4. The materials exhibit low absorption in the visible region. It also exhibit absorption peak at ~ 290 nm. The absorption peak is broad enough. This can be due to the dispersive nature of the size variation of the nanoparticles.

The band gap of the synthesized CuO nanoparticles was calculated using Tauc equation [6]:

$$\alpha h\nu = D\left(h\nu - E_g\right)^n,$$

where the term $h\nu$ is the energy of the incident photon E_g, is the band gap of the semiconducting material, D is a constant. The transition data enables us the best linear fit in the band edge region for $n = 1/2$. Plot of $(\alpha h\nu)^2$ vs $h\nu$ is shown in Fig. 5.

An extrapolation of the linear portion of the graph to the $h\nu = 0$ axis, the band gap was calculated to be 1.54 eV.

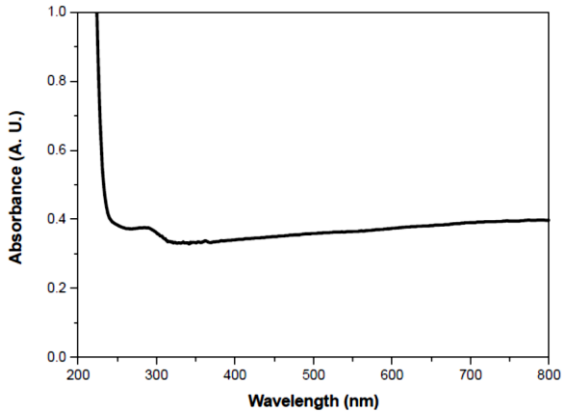

Fig. 4 – UV-visible spectrum of Copper Oxide nanoparticles

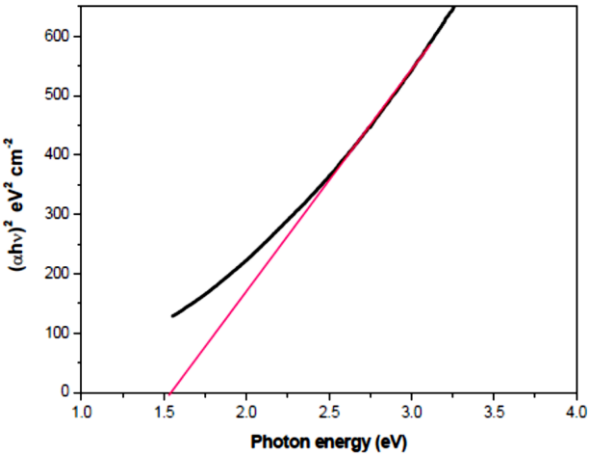

Fig. 5 – Plot from UV-VIS data to determine band gap of synthesized copper oxide

4. CONCLUSIONS

In conclusion, we have successfully synthesized copper oxide nanoparticles. The size of the synthesized nanoparticles is ~ 80 nm. TEM image revealed the formation of almost spherical nanoparticles. The sizes of the nanoparticles are not uniform. This indicates the bottom up growth of the nanoparticles.

The nanoparticles show strong UV-visible absorption at ~ 290 nm. The band gap of the CuO nanoparticles was calculated from the absorption data. The band gap was found to be 1.54 eV. The nanoparticles exhibit low absorption in the visible region and thus can be used for transparent coatings in solar cells.

REFERENCES

1. P.K. Samanta, A. Saha, T. Kamilya, *Recent Patent. Nanotechnol.* **10**, 20 (2016).
2. P.K. Samanta, *Adv. Sci. Eng. Med.* **7**, 811 (2015).
3. H.D. Banerjee, R. Viswanathan, D.R. Rao, H.N. Acharya, *Opt. Eng.* **27** No 11, 271133 (1988).
4. S. Jana, S. Das, N.S. Das, K.K. Chattopadhyay, *Mater. Res. Bull.* **45**, 693 (2010).
5. A.M. Awwad, B.A. Albiss, N.M. Salem, *SMU Medical Journal* **2** No 1, 91 (2015).
6. P.K. Samanta, T. Kamilya, A.K. Bhunia, S. Mandal, *Adv. Sci. Eng. Med.* **8**, 240 (2016).