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SYNTHESIS OF NANOSIZED CuO PARTICLES : A SIMPLE AND EFFECTIVE METHOD

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ABSTRACT

Nanosized metal oxide namely copper oxide has been synthesized by precipitation method and characterized by using XRD (X-ray diffraction), TEM (transmission electron microscopy) and Magnetic measurements techniques. XRD studies show that copper oxide was formed as CuO and it has monoclinic structure. Magnetic measurements showed copper oxide has one unpaired electron and is paramagnetic in nature. The particle size of the synthesized copper oxide was determined by TEM. TEM images show that the size of particles of CuO varied from 12 nm to 35 nm, which is in good agreement of the theoretically predicted size of nanomaterials. This method is convenient, easy and effective in comparison to the known methods of the synthesis of nanomaterials like thermal decomposition of precursors, co-implantation of metal and oxygen ions and ultrasonic spray pyrolysis.

Key words: Nanaomaterial, copper oxide, TEM, Metal oxides, XRD analysis

INTRODUCTION

Transition metal oxides have many applications as catalyst[1-5], sensors[6-9], superconductors[10,11] and adsorbents[12,13]. Among transition metals oxides, 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%[14]. CuO is a semiconducting compound with a narrow band gap and used for photoconductive and photothermal applications[15]. Very few methods of synthesis of copper oxide particles have been reported as compared to other oxides. CuO particles have been synthesized using different methods like sonochemical method[16], sol-gel technique[17], one-step solid state reaction method at room temperature[18], electrochemical method[19], thermal decomposition of precursors[20], co-implantation of metal and oxygen ions[21] and ultrasonic spray pyrolysis[22]. A novel nano-sized copper oxide modified carbon

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paste electrode has been fabricated to determine the amikacin by cyclic voltammetry and amperometry. The oxidation current of the amikacin on nano-sized copper oxide modified carbon paste electrode was about 40 times higher than that on bulk CuO modified carbon paste electrode[23]. Nanosized copper ferrite spinel particles by a precursor approach with the aid of ultrasound radiation have been synthesized[24]. Influence of various preparation parameters on the formation of copper ferrite was studied. The preparation parameters included concentrations of precipitation agents and copper salt, sonochemical reaction time, calcination temperature and time. The reactions for the formation of $CuFe_2O_4$ were explored by analyzing X-ray diffraction data obtained under different processing conditions. Nano-powders of p-type transparent conductive copper aluminium oxide (CAO) by co-precipitation method by adding sodium hydroxide into the mixed solution of copper chloride and aluminium chloride have been synthesized[25]. Co-precipitate precursors of CAO with particle size around 50-60 nm were produced after washing, filtering, and drying of the co-precipitates, nano-powders of copper aluminium oxide were produced when the dried co-precipitate precursors were calcined at temperature above 1100^{o}C. 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 nanaoparticles. The obtained particles of CuO have size from 12-35 nm. The synthesized nanoparticles were characterized by XRD, magnetic susceptibility and TEM.

EXPERIMENTAL

Methods and materials

Chemicals

All chemicals used in the experiment were of analytic reagent grade. Copper nitrate $Cu(NO_3)_2$ was purchased from Merck, India. Ammonium hydroxide (liquor ammonia) was purchased from SRL. Deionized water was used throughout the experiment.

Synthesis of copper oxide

Copper oxide was synthesized by using 500 mL of 0.5 M solution of $Cu(NO_3)_2$ and aqueous ammonia.

Equipments

The powder X-ray diffraction (XRD) was performed using X-ray diffractometer system Philips PW 11/90, with nickel filtered CuKα (l = 1.5405 Å) radiation. Magnetic measurements were done using vibrating sample Magnetometer Model 155. The transmission electron microscopy (TEM) was performed with Tecnai 20G2 under 200 KV.

RESULTS AND DISCUSSION

X-ray studies

X-ray diffraction of synthesized oxide is shown in Fig. 1. X-ray diffraction pattern of pure copper oxide indicated that copper oxide in the form of CuO Fig. 1. (In X-ray diffraction, some prominent peaks were considered and corresponding d-values (2.52028, 2.31782, 1.86566….) were compared with the standard [JCPDS file No. 05-661] (Table 1). X-ray diffraction shows that metal oxide is pure CuO having monoclinic structure.

Table 1: X-ray diffraction data for copper oxide

S. No.	$d = \lambda/2 \sin\theta$ (Observed)	$d = \lambda/2 \sin\theta$ (Reported)	$I/I_0 \times 100\%$ (Observed)	$I/I_0 \times 100\%$ (Reported)
1.	2.52028	2.519	100	100
2.	2.31782	2.314	80.46	70
3.	1.86566	1.851	17.24	15
4.	1.50415	1.492	12.76	11
5.	1.40758	1.320	11.27	10
6.	1.37337	1.311	10.43	8

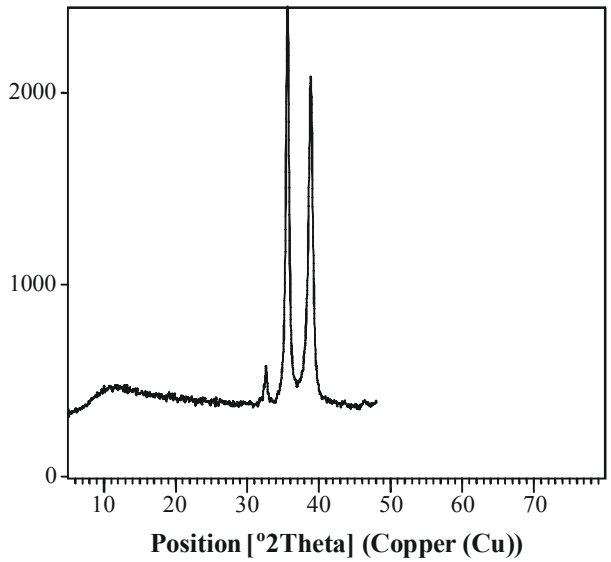

Fig. 1: XRD spectra of synthesized copper oxide

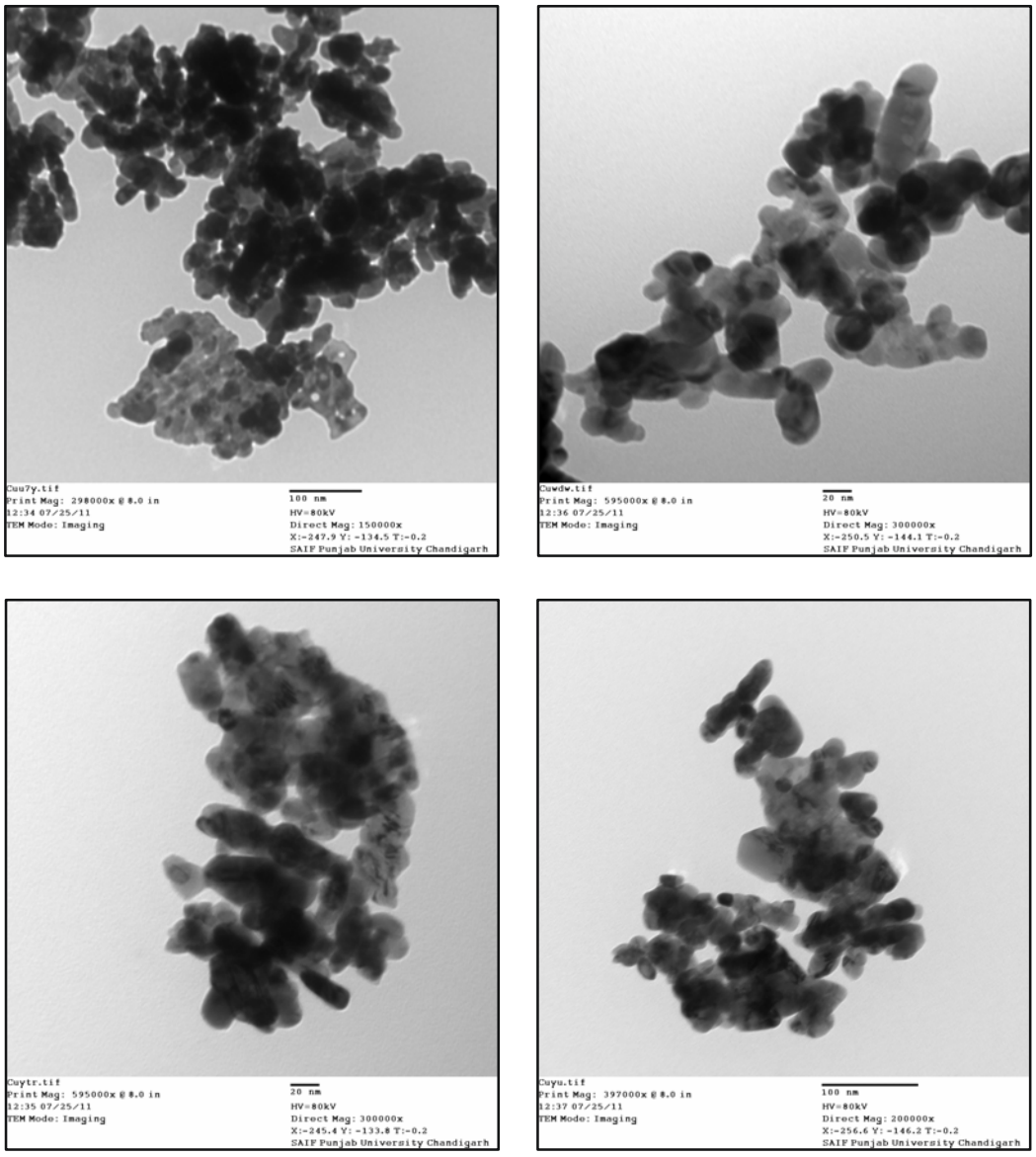

Fig. 2: TEM images of copper oxide particles

Magnetic measurements

The magnetic moment for copper oxide was found to be 1.731 B.M. This value of magnetic moment supports the fact that the formed copper oxide is in the form of CuO with actual magnetic moment 1.732 B.M. This indicates that an unpaired electron is present in CuO. Thus the oxide formed is paramagnetic in nature.

TEM studies

TEM studies were performed to find out exact particle size of synthesized CuO. Figure 2 shows the TEM image of the synthesized CuO nanoparticles. It shows that the CuO nanoparticles are monoclinic and size of the obtained nanaoparticles is in the range of 12-35 nm.

CONCLUSION

CuO nanoparticles with monoclinic structure were synthesized successfully by aqueous precipitation method. From TEM study, it was found that particles were monoclinic with average size of 12-35 nm. Magnetic measurements shows that CuO has one unpaired electron and hence paramagnetic in nature. This method is advantageous over the existing methods of synthesis of nanoparticles because other methods require specialized instrumentation, highly skilled labour, expensive materials and methods. Therefore, the proposed precipitation method is very promising and may have extensive applications.

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