Nanotechnological Applications of Copper Oxide Nanoparticles and its correlation with Structural and Magnetic Properties

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ABSTRACT: *Using XRD (X-ray diffraction), TEM (transmission electron microscopy) and magnetic measurement techniques," metallic nano oxide, i.e. copper oxide, was synthesized. Studies on XRD show that copper oxide has a monoclinic structure and is formed as CuO. Magnetic experiments have shown that there is an unpaired electron in the copper oxide, which is of the paramagnetic type. "The particle size of the synthesized copper oxide was calculated by TEM. TEM images show that the particle size of CuO ranged from 12 nm to 35 nm, in line with the theoretically predicted size of the nano material." Compared to proven nanomaterial synthesis methods, such as thermal decomposition of precursors, metal-oxygen ion co-implantation and ultrasonic pyrolysis, this method is economical, fast and reliable.*

Key Words: *Nanomaterial, copper oxide, TEM, XRD analysis*

1. Introduction:

"Catalysts [1-5], sensors [6-9], superconductors [10-11] and adsorbents" [12-13] are widely used as transition metal oxides. "Because of their effectiveness as nanofluids in heat transfer applications, copper oxide nanoparticles are of particular interest" among transition metal oxides. It has been claimed that adding 4% CuO increases "the thermal conductivity of water by 20% [14]. CuO is a compound used for photoconductive and photothermal applications with a narrow band semiconductor" [15-19]. Very few methods of synthesis of copper oxide particles compared to other oxides have been published. CuO particles were synthesized using various methods, such as the sonochemical method [20], the sol-gel technique [21], the solid state reaction method at room temperature [22], the electrochemical method [23], the precursors of thermal decomposition [24], metal and oxygen. Ionic co-implantation [25] and spray method with ultrasonic pyrolysis [26]. A new nanometer-sized modified carbon paste electrode was designed to use voltammetry and cyclic voltammetry to test amikacin. The oxidation pressure of amikacin with in carbon paste electrode adjusted by nano-sized copper oxide is roughly 40 times greater than with the carbon paste electrode modified by CuO [27]. Using a precursor approach, nanometer-sized copper and spinel ferrite particles were synthesized with ultrasonic radiation [28]. The effect of different preparation parameters on the formation of copper ferrite was investigated. The parameters for the preparation included the concentrations of the precipitating agent and the copper salt, the sonochemical reaction rate, the temperature and the time of calcination. The reactions to the formation of CuFe2O4 were investigated by examining the X-ray diffraction data obtained under different processing conditions. The coprecipitation method was used to synthesise P-type transparent copper conductive aluminium oxide (CAO) "nano powders by adding sodium hydroxide to the mixed solution of copper chloride and aluminium chloride" [29]. After washing, filtering, and drying the coprecipitates, copper oxide, and aluminium nanopowders, CAO precursor coprecipitates with a particle size of about 50-60 nm were created. We synthesised CuO nanoparticles using a simple aqueous precipitation process in this manuscript. This technique requires a simple one-step procedure for the CuO nanoparticles to be synthesised. The sizes for the CuO particles range from 12 to 35 nm. The nanoparticles synthesised included XRD, magnetic susceptibility, and TEM.

2. Methods and materials

2.1 Chemicals:

"All chemicals used in the experiment are 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".

2.2 Synthesis of copper oxide:

500 ml of 0.1 M Cu (NO3) 2 solution were taken and, under continuous stirring, aqueous ammonia was added until the pH of the solution reached 10. The Buckner funnel filtered the precipitates thus collected and washed. with purified water several times. The precipitates were dried in an oven at 70 ° C for 24 hours

and calcined in a muffle furnace for 5 hours at 400 ° C. The material was ground and sewn onto a 100 mesh net.

2.3 Equipments:

"Powder X-ray diffraction (XRD)" was performed with CuKa filtered nickel radiation (l = 1.5405 Å) using the Philips PW 11/90 X-ray diffracto meter process. A vibrating sample of the 1555 magnetometer was used to obtain magnetic measurements. "Transmission electron microscopy (TEM) with Tecnai 20G2 below 200 KV".

Results and discussions:

3.1. X-ray studies:

The X-ray diffraction of the synthesised oxide is shown in figure (1). The pattern of X-ray diffraction of pure copper oxide indicated CuO [Fig-1] to be the copper oxide. In the X-ray diffraction, some prominent peaks were considered and the corresponding d values (2.52028, 2.31782, 1.86566 ...) were compared to the standard ones [JCPDS file n. 89-5899] [Chart-1]. X-ray diffraction shows the metal oxide to be pure CuO with a monoclinical structure. The crystal thickness was calculated using Scherrer 's formula and ranged between 12 nm and 40 nm [Table 1].

3.2 Magnetic measurements:

Copper oxide has a magnetic moment of "1.731 B.M. This value of the magnetic moment encourages copper oxide formation as CuO with an effective magnetic moment of 1.732 A.M. This shows 1 unpaired electron in CuO." This is how rust developed with normal paramagnetic.

3.3 TEM studies

In order to determine the exact size of the synthesised CuO particles, TEM experiments were conducted. "Figure 2 displays the TEM image of the nanoparticles with synthesised CuO. It shows the nanoparticles obtained are 12-35 nm in scale." The thickness measured using Scherrer 's formula (12 nm – 40 nm) is in good agreement.

4. Conclusion:

CuO nanoparticles with a monoclinic structure are successfully synthesized by the aqueous precipitation metho The particles have an average size of 12-35 nm from the TEM sample. Magnetic experiments indicate that CuO paramagnetic in nature and has an unpaired electron. This approach advantages over methods of synthesis nanoparticles, because other methods involve sophisticated instrumentation, highly qualified staff, cost materials and methods. The proposed method of precipitation is therefore very promising and can hav comprehensive applications.

Table-1 X-RAY DIFFRACTION DATA FOR COPPER OXIDE

S. No.	d=λ / 2sinθ (Observed)	d=λ / 2sinθ (Reported)	$I/I_0X100\%$ (Observed)	$I/I_0X100\%$ (Reported)	Thickness of crystal size (t nm)
1.	2.52028	2.519	100	100	40
2.	2.31782	2.314	80.46	70	31
3.	1.86566	1.851	17.24	15	32
4.	1.50415	1.492	12.76	11	17
5.	1.40758	1.320	11.27	10	20
6.	1.37337	1.311	10.43	8	20
7.	2.74600	2.7485	9.60	10.21	30
8.	1.71104	1.7093	4.64	9	13
9.	1.57843	1.5799	7.70	12.1	30
10.	1.30206	1.30337	4.37	5.5	21
11.	1.26380	1.2641	6.51	4.3	12

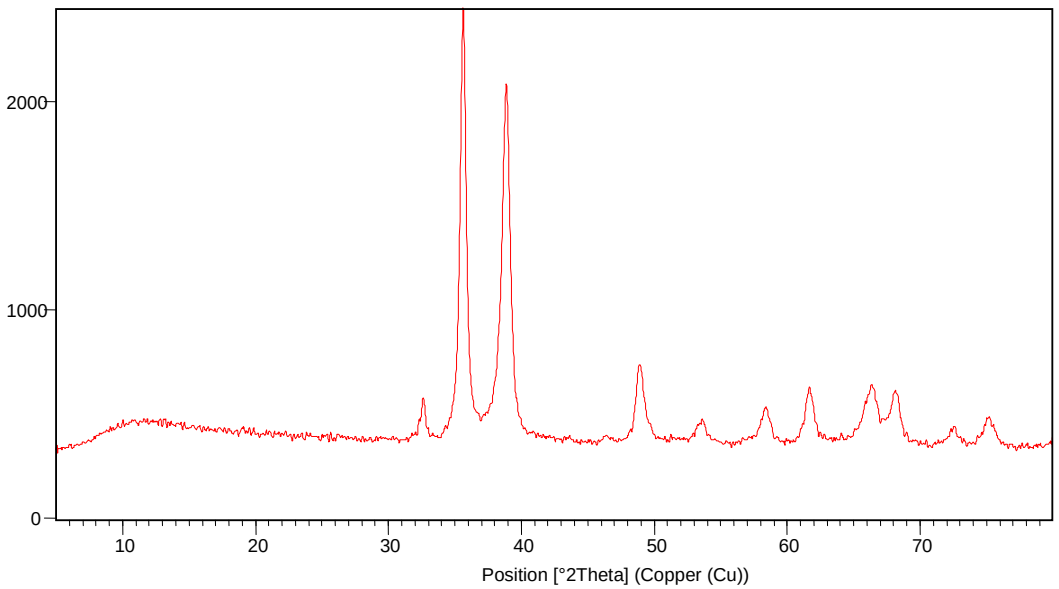
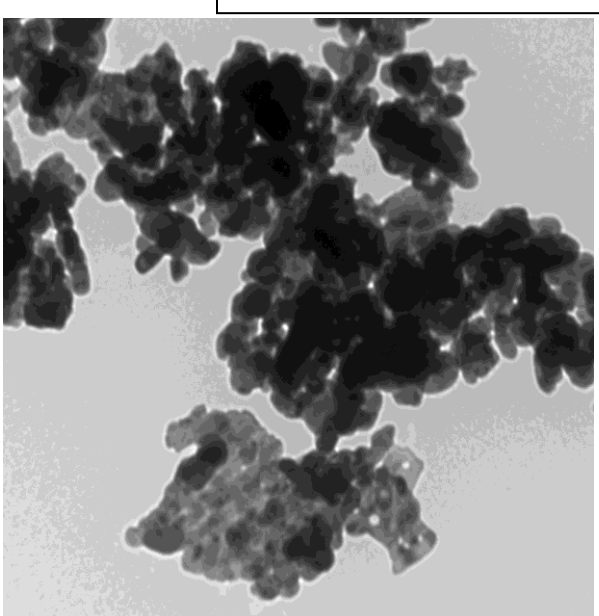
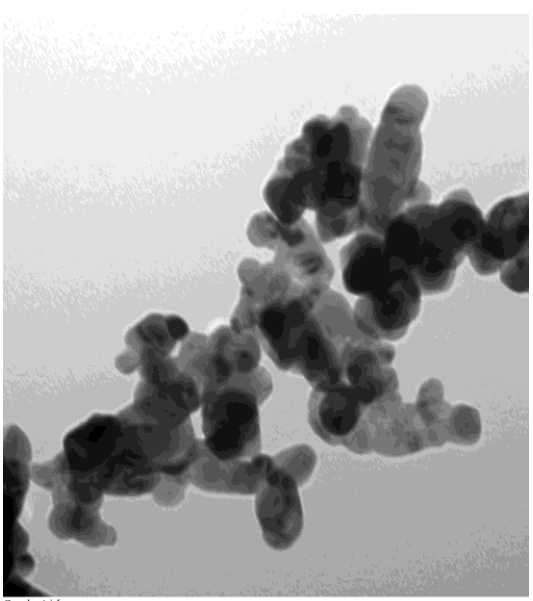


Fig.1- XRD spectra of synthesized copper oxide





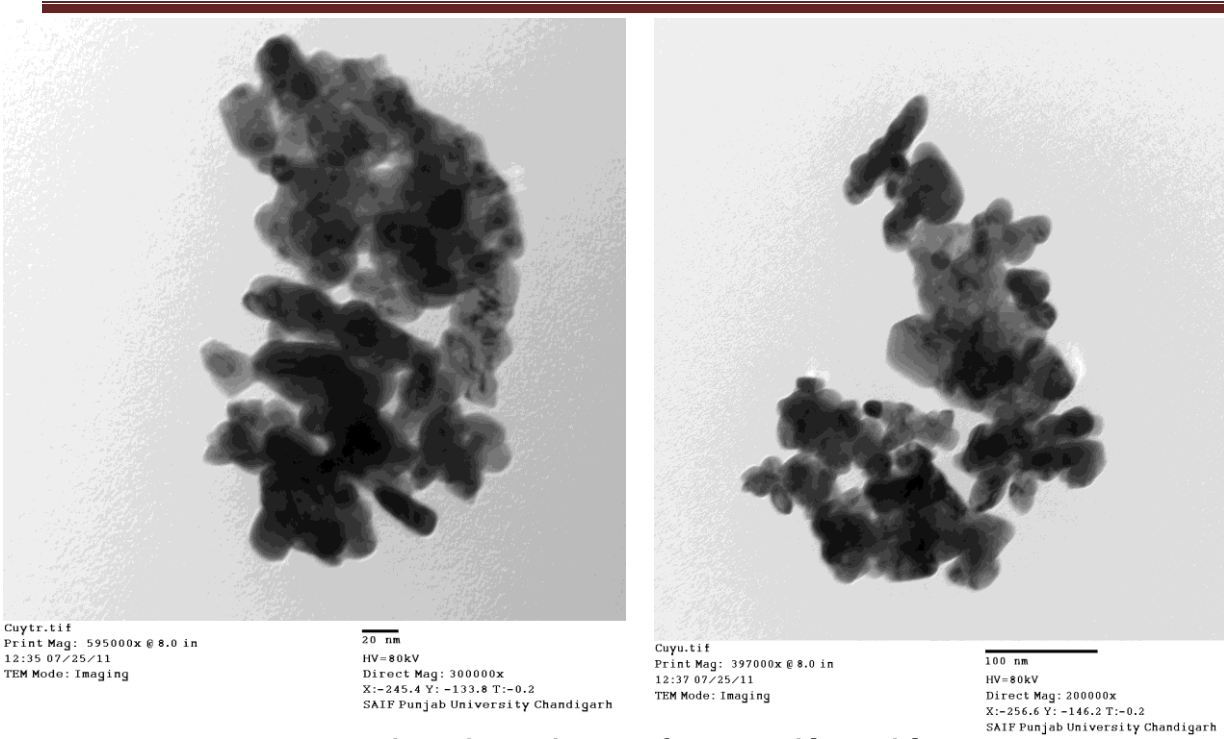


Figure 2: TEM images of copper oxide particles

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