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Optical Properties and Synthesis of CuO Nanoparticles by Co-Precipitation Method

Rajesh Kumar[1], Ashwani Sharma[2], Nawal Kishore[3]

[1, 2]Department of Physics, M. D. University, Rohtak (India)
[3]Department of Applied Physics, GJUS&T, Hisar (India)
rkkaushik06@gmail.com

Abstract

In the development of nano size materials of metal and metal oxides nanoparticles are intensively pursued because of their important properties in different fields of applications in science and technology.In all the transition metal oxides, CuO is a potential material for anti-bacterial product, magnetic storage devices, solar energy transfer, sensors, and super capacitors and especially it acts as a good catalyst in some of the chemical reactions. CuO Nano particles are prepared by novel co-precipitation technique. In this technique $CuCl_2.6H_2O$ is added with deionised water with ammonia solution as precipitating agent with continuous stirring. Control the pH of solution, ammonia is added to the solution till pH reaches desired value. The color of the solution changed from blue to black with precipitation. The black precipitation was washed 3-4times with distill water and ethanol . Finally it was filtered and dried in air for one day. The CuO Nano particles were characterized for the studying of their structure and composition from X- ray diffraction, FTIR Spectroscopy, for the morphology test SEM and TEM carried out.

Keywords: *CuO Nano-particles, Co-precipitation method, Novel applications.*

1. Introduction

In the world there are number of metal oxides are available but some of the metal oxides are most useful in accordance with their applications in science and technology to reduce the size of imstrument and increase the application. In the periodic table transition metals are large in number and have number of applications in different fields of applications. Some transition metal oxides like ZnO , SnO_2 TiO2, Co_2O_3 and Fe_3O_4 etc proved as potential material for so many drastic applications[1]. In the same way CuO is also one of the useful metal oxide, which has so many applications in different fields of science . The unique property of CuO is it acts as a semiconductor and of their great practical importance in fabrication of microelectronic and optoelectronic devices, such as electro chemical cell, gas sensors[2], magnetic storage devices[3], antibacterial oinment[4], high- critical temperture superconductors[5] and catalysts[6] etc. Due to the potentiality of CuO, it acts as a catalyst ; whereas many metal oxides are not used for the catalytic activity. As like Fenton's reagent CuO combined with another metal oxide like CeO2, CuO is used in waste water treatment. Electrical applications like super capacitors CuO is very useful in electrical and in Nano range it has the wide band gap nearly equal to ZnO. The favorable band gap of CuO makes it useful for solar energy conversion and it can be used for production of solar cell and Nano fluids is acts as a coolants in refrigerators, these Nano fluids mixed with carrier liquid then it enhance the energy transfer comparatively carrier liquid alone. CuO can be used as coolant material and it can control effectively the temperature like other coolants like TiO_2, alumina and silver particles[7] etc. The properties of Nano materials will depends mostly on the size, morphology ,method of synthesis and specific surface area of the synthesized materials. Nano materials are differenciate from the bulk counterpart on the basis of large surface to volume ratio. In Nano scale it was observed that the quantum confinement effect was a lot of influence on the material optical properties. In present work CuO Nanomaterials were synthesized by Co-precipitation method and as-synthesized material is characterized with XRD, FTIR, SEM and TEM, structural disorder change the properties of materials in the applications part, in different fields in science and technology. There were many methods among those Co-precipitation method preferable and widely used in the synthesis of Nanoparticles. CuO Nano particles is around 5-10nm [8], sonochemical method is around 10 nm to

several microns[9]. Some results shows in some references which is in the range of 1-20 nm CuO Nano particles in Sol-Gel method[10]. The average diameter of the CuO Nano particle in solid state reaction is given by 15-20nm[11]. Smallest CuO Nano particle was prepared by electro chemical method [12].

2. Experimental Details

Synthesis: All the chemicals used were analytic grade and not further purified 0.1M of $CuCl_2.2H_2O$(HIMEDIA, India)) was prepared in 100ml of deionized water. Then NH_4OH solution was injected to the above solution at 100°C under constant stirring so that white precipitate were form in blue solution, and the resulting mixture was refluxed at the same temperature for 24hrs. After the reaction was complete, the resulting white precipitate was washed with de-ionized water and ethyl alcohol for several times to remove the by-products or impurities .Now dried in air at 100°C for 4hr. The as-synthesized material was calcinated at 600°C for 4hrs and 6 hrs in air to obtain CuO. The structural properties CuO nanoparticles were analyzed by XRD using a panalytical's Xpert-pro powder diffractometer employing Cu –Kα radiations in the 2 θ range 10^0-90^0.FTIR was recorded on FTS-165 spectrometer. The morphology of the nanoparticles was analysed using JSM-6360 JEOL TEM. The optical band gap of the nanoparticles was estimated from DRS using JASCO V- 670 double beam spectrophotometer.

3. Results and Discussion

3.1 XRD analysis

X-ray Powder Diffraction (XRD) studies were carried out to confirm the the structure (crystallinity) using X-ray diffractometer with Copper (kα) radiation (λ = 1.5418 Å) in the range of 10–80° in steps of 0.0170 at a scan speed 0.4°/min. The XRD pattern is shown in Fig.1.

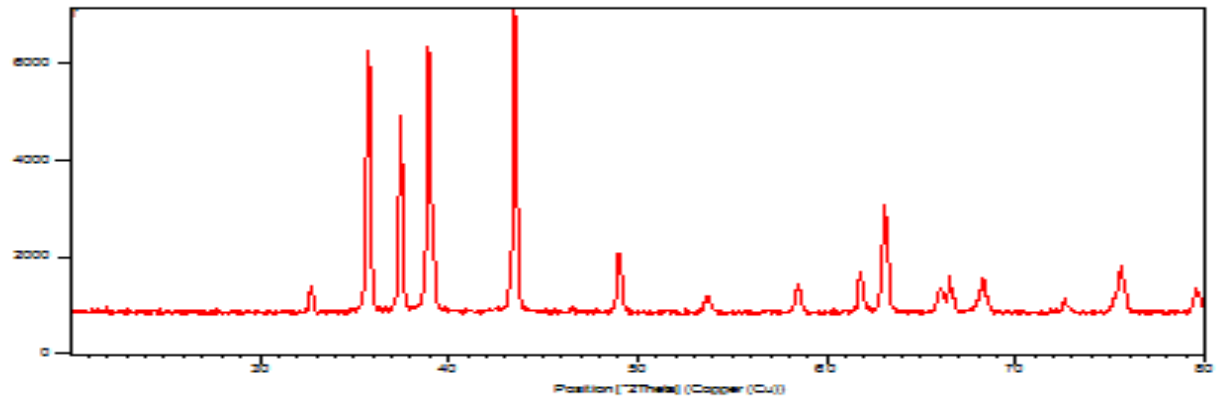

Figure 1 XRD OF CuO nanoparticles at 600 °C(4HRS)

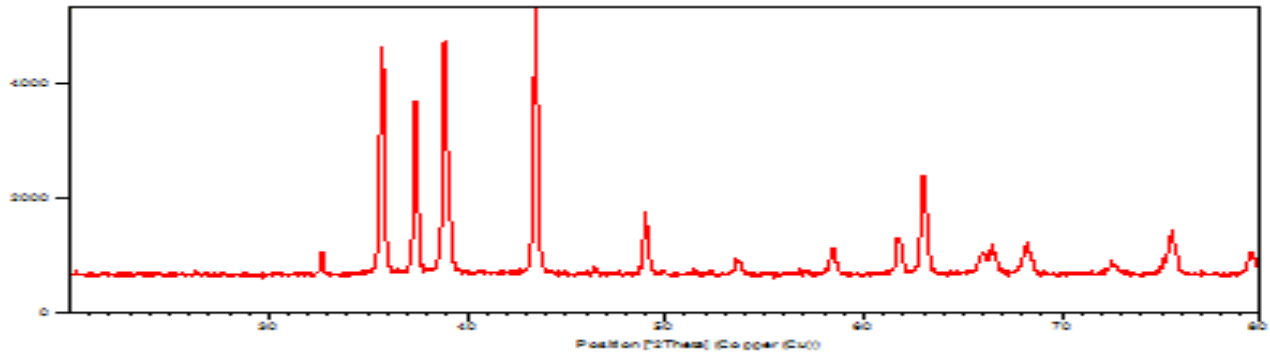

Figure 2 XRD OF CuO nanoparticles at 600 oC (6HRS)

The spectrum reflect the good crystallinity for MgO nanoparticles.The highest peaks position (2**θ**)of CuO nanoparticles were at 43.5164 & 43.8396, change in peaks show that particle size increase with increase the sintering

time. All the diffraction peaks can be indexed to the face-centered cubic structure of CuO (JCPDS card No: 78-0430). No characteristics peaks of $Cu(OH)_2$ and other impurities was detected in the XRD pattern Considerably broadened lines in the XRD patterns are indicative of the presence of nano-size particles. The XRD patterns is used for obtaining the average particle size with the help of Debye - Scherrer's equation

$$D = 0.9 \lambda / B \cos \theta$$

where D is the crystallite size, λ is the X-ray wavelength ,β is the full width at half maximum of the diffraction peak, and θ is the Bragg diffraction angle of the diffraction peaks. The calculated average particle sizes for MgO nanosamples were 16 nm and 19 nm respectively. It shows that increase the heating time the size of the sample increase.

3.2 FTIR Study

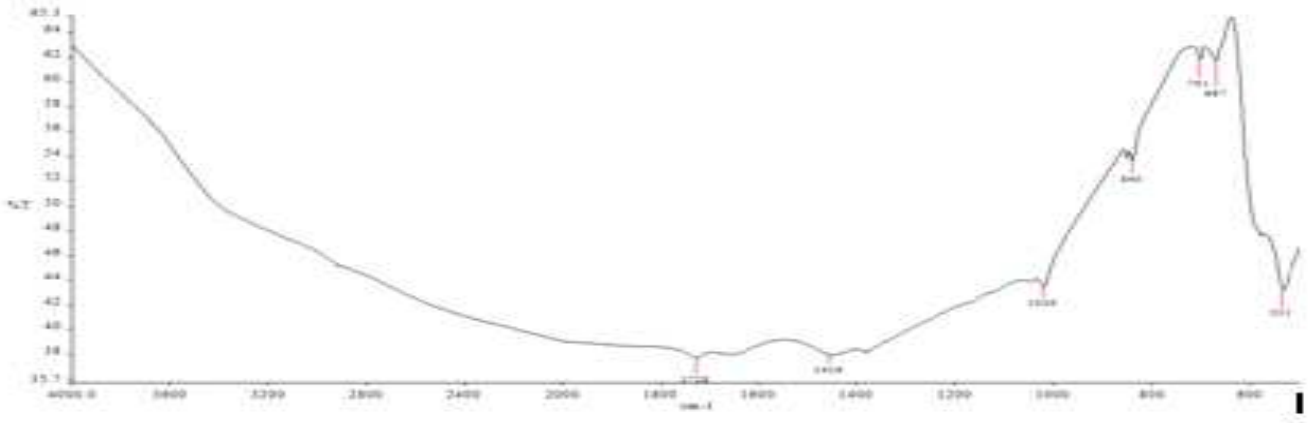

Fig. 3 FTIR Spectroscopy of CuO nanoparticles

The sharp and intense peak at 3400cm-1 is attributed to the OH antisymmetric stretching vibration in the crystal structure of Cu (OH)2 due to water presence. The peak at 619cm^{-1} is assigned to the Cu–O stretching vibration [12]. The absorption peaks at 1728cm^{-1} and 1456 corresponds to the bending vibration of OH bond and Cu–OH stretching vibrations respectively. The other absorption solder peaks at 1020cm^{-1} is due to the stretching and the bending vibration of water, Bands around 840 may be due to Cu-O stretching viberation respectively [13].

3.3 TEM and SEM studies

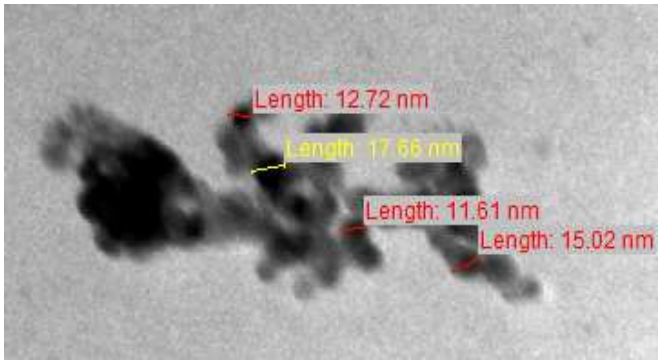

Figure 4 TEM of CuO Nanoparticles

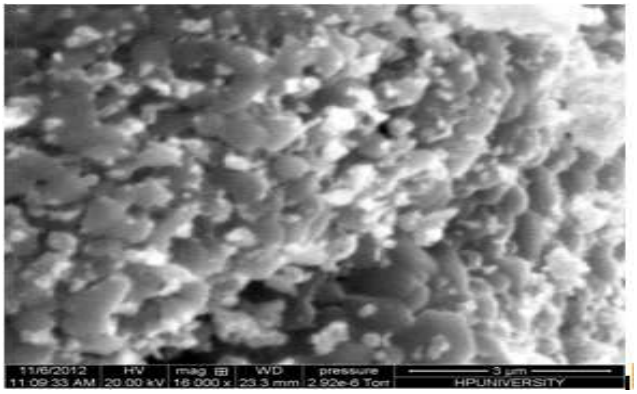

Figure 5 SEM of CuO Nanoparticles

The Transmission electron microscopy (TEM) and scanning electron microscopy measurement was carried out in AIIMS , Delhi instrument in order to analyze the structure and morphology of synthesized CuO nanoparticles. It shows that higher tendency of agglomerations. We collect the SEM images in different scales most of the images given particle size are in micrometer . From The TEM images the particle sizes of the CuO nanoparticles were found to be in the range 10-17 nm, which is in quite accordance with the reported value. It is also clear that the synthesized CuO nanoparticles sample is very hygroscopic and monodispersal in nature .

4. Conclusion

CuO nanoparticles can be synthesized in nano-scale in the presence of ultrasonic waves . XRD pattern revealed copper oxide Nano particles have monoclinic structure . From XRD analysis the copper oxide Nano particles are pure and free from impurities. TEM photo graph shows all particles size good agreement with the size of XRD calculations..The CuO nanoparticles can be used as Bacteriocide , so used for water purification [20]. We also see toward other property of MgO nanoparticles in future.

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