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Synthesis and Characterization of Zinc Doped Copper Oxide Nanocrystals by Chemical Precipitation Method

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Abstract

Zinc doped copper oxide nanoparticles were synthesized by chemical precipitation method. Copper acetate is act as a precursor and sodium hydroxide will act as a reducing agent. The prepared nanoparticles were characterized by X-ray diffraction (XRD) which reveals the simple monoclinic structure. The Fourier Transform Infrared Spectroscopy confirms the functional groups present in the nano powders. The morphological Structure of the prepared crystals are analyzed by Scanning Electron Microscopy (SEM) were showed that the products consists of flaky in nature. The Bandwidth of the synthesized sample was calculated by UV- visible spectrum. The presence of compounds in nano powders were confirmed by Energy Dispersive X-ray diffraction (EDAX). Copper oxide has applications as a P-type semiconductor, because it has a narrow band gap of energy of 1.2 e V. Zinc doped copper oxide has applications in the wide variety of fields such as medicine, industries, sunscreens, agriculture etc.

Keywords: XRD, SEM, FTIR, UV, EDAX.

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1. Introduction

Nanotechnology is a field of applied science focused on the design, synthesis, characterization and application of materials and devices on the nano scale.[1] A nanotechnology is a fast growing area of researchers in all over the world. Nano materials are corner stone's of Nanoscience and nano technology is a board interdisciplinary area of research and development activity that has been growing explosively worldwide in the past few year. Nanotechnology[2] includes the integration of nanoscale structures into larger material components and systems, keeping the control and constructionofnewandimprovedmaterialsatthenanoscale.[3] The chemical precipitation method is one of the most appropriate ways of synthesizing a nano powder. Chemical precipitation is the name given by analytical chemists to a phenomenon whereby the fractional precipitation of a specified ion in a solution results in the precipitation not only of the target ion but also of other ions existing side by side in the solution. The additional precipitation of unwanted ions is, of course, an impediment to the analytical process.[4] Zinc oxide nanoparticles is non-toxic, the band gap energy also identified by using semiconductor material for exhibiting ferromagnetism at room temperature.[5] Zinc oxide nanoparticles were extensively studied for their implications in cancer therapy.[6] Copper oxide nanoparticles have special interest because of their efficiency as nano fluids in heat transfer applications.[7] Copper oxide nano powders are of a great importance among the various metal nanoparticles due to their low cost of preparation and excellent physical and chemical properties. Copper oxide has extensive solicitations as temperature transfer system, super strong materials, catalysts and sensors.[8] Different nanostructures of copper oxide are synthesized in form of nanowires, nanorods, nano needle, nano flower and nanoparticles.

2. Experimental Procedure

The zinc doped copper oxide nano particles were synthesized by dissolving 2g of copper acetate in 50ml distilled water and allowed to stirrer in magnetic stirrer for few minutes. Then the preferred mole of Zinc acetate of 0.08 M was dissolved in 20ml distilled water stirred for 10 minutes and it was added drop by drop to the above solution. To the above solution 1.2g of sodium hydroxide (NaOH) pellets was dissolved in 20ml of deionised water and it was added

drop by drop and it was stirred at 60° C at 650 rpm for one and half hours until a black precipitate was obtained. The obtained solution was kept at rest for one day. The removal of impurities was done by washing the obtained precipitate with ethanol and distilled water for several times. Then washed precipitate was dried in hot oven at 100° C for 24 hrs. The final product was annealed in muffled furnace at 400° C for 2 hrs. Finally, the Zn doped copper oxide nano particles were synthesized.

3. Results and Discussions

3.1 XRD Analysis

The crystallography analysis of the nano powders was investigated by XRD diffraction method. The XRD pattern of Zn doped CuO is shown in Fig. Then the sharp peaks showed that the synthesized powders were nano crystalline nature. The crystallite size of the Zn doped CuO were calculated using Debye Scherrer formula

$$D=k\lambda / \beta \cos\theta$$

Where,

D= crystallite size in nanometers,
λ= Wavelength of the radiation,
k= constant equal to 0.94,
ß= full width half maximum of the peak in radiance (FWHM)
θ= Diffracted angle of X-ray pattern

The calculated average crystalline size of the Zn doped CuO from XRD pattern and various parameters.

3.2. Fourier Transform Infrared Spectroscopy analysis

The FTIR spectrum of zinc doped copper oxide nanoparticles synthesized by chemical precipitation method is shown in figure5.2 respectively. The wavelength region was recorded in the range 400-4000cm^{-1}. The absorption peak at 3037.89cm^{-1} corresponds to the O-H alcohol stretching. The absorption peak at 2748.56cm^{-1} corresponds to the C-H aldehydes stretching. The absorption peak at 989.48cm^{-1} corresponds to the C=C alkane bonding. The absorption peak at 1068cm^{-1} corresponds to the S=O Sulfoxide stretching.

Table 2: FTIR parameter of Zn doped CuO nanoparticles

Wave number(cm^{-1})	Band Assignment
3037.89	O-H Stretching
2748.56	C-H Stretching
989.48	C=C Stretching
2358.94	N=C=O Stretching
1068.56	S=O Stretching

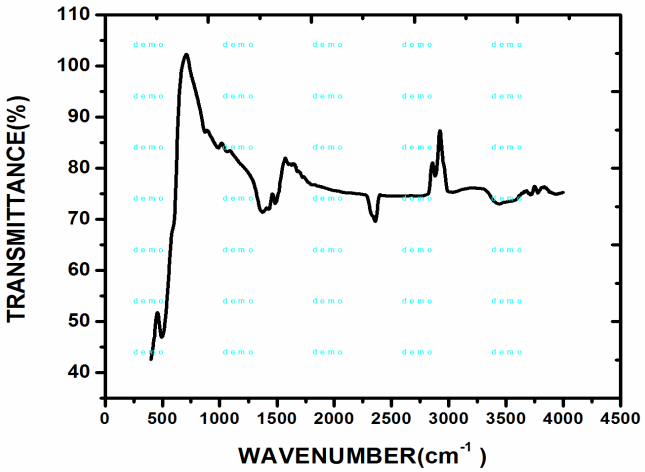

Fig. 1: FTIR Spectra Zn doped CuO nanoparticles

3.2 UV-Visible Spectroscopy studies

The optical properties of Zn doped CuO nanoparticles are characterized by UV-visible absorption spectrum of Zn doped CuO Aare shown in the fiure1.2. The optical absorption spectrum of the samples was recorded in the range of 200-400nm. The band gap energy can be calculated using the formula

$$E=h\,c / \lambda_{max}$$

Where,

h = Planck's constant (6.626 x 10^{-34} J sec)
C =Wavelength of light (3x10^{8}m/s)
λmax =Cut of wavelength (m)

The band gap energy was calculated to be 1.17eV, similar to that of standard value of CuO band gap. From the UV-visible spectroscopy it was observed that the absorbance of CuO nano particles decreases with

Table 1: Structural parameters of Zn doped CuO

Sample Name	2θ (deg)	Inter planar spacing	FWHM (deg)	Crystallite size (D)x10^{-9}	Average crystallite size(D)x10^{-9}	Dislocation Density 10^{-3}	Micro strain
Zinc doped copper oxide	35.6622 38.9236 36.4000	2.51558 2.31198 2.46626	0.75490 0.83780 0.58180	11.1136 10.5092 15.020	12.2143	8.0963 9.0542 4.4324	3.257 3.444 2.410

Table 3: UV- Vis data of Zn doped CuO nanoparticles

Sample	Absorption	Band gap(eV)
Zinc doped copper oxide	1056	1.17

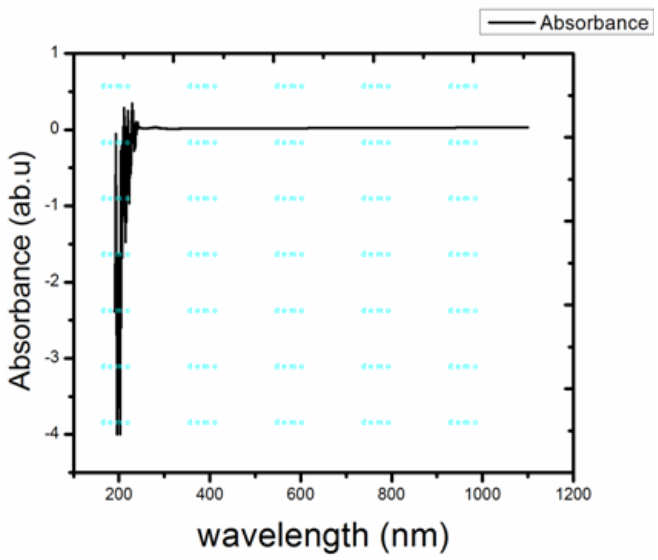

Fig. 2: UV-Vis Spectra of Zn doped CuO nanoparticles

increases in wavelength. The calculated band gap energy for the samples is tabulated.

3.3Scanning Electron Microscopy (SEM) analysis

The surface morphology of zinc doped copper oxide nano powder synthesized by chemical precipitation method is analyzed using scanning electron microscope. The SEM image of nano zinc doped copper oxide powder is shown in figure1.4. The SEM image of images of zinc doped copper oxide particles show a nano flakes in nature.

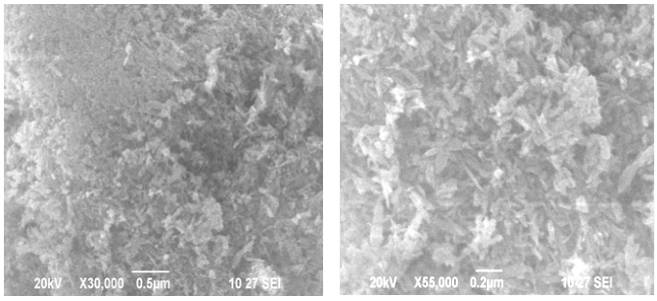

Fig. 3: SEM image of Zn doped CuO nanoparticles

3.4 EDAX Analysis

The chemical composition of zinc doped copper oxide nanoparticles prepared at the optimized conditions was extracted from the energy dispersive X-ray spectrum (EDAX) which is shown in Figure.4. The EDAX analysis exhibited clear peaks of analysis exhibited clear peaks of only Zn, Cu and

Table 4: EDAX analysis of Zn doped CuO nanoparticles

El	Series	C norm. [wt]	C Atom. [at. %]	C Error (1 sigma) [wt%]
Zn	k-series	29.62	62.65	0.80
O	k-series	61.47	32.74	0.94
Cu	k-series	8.90	4.61	0.83
Total			100.00	100.00

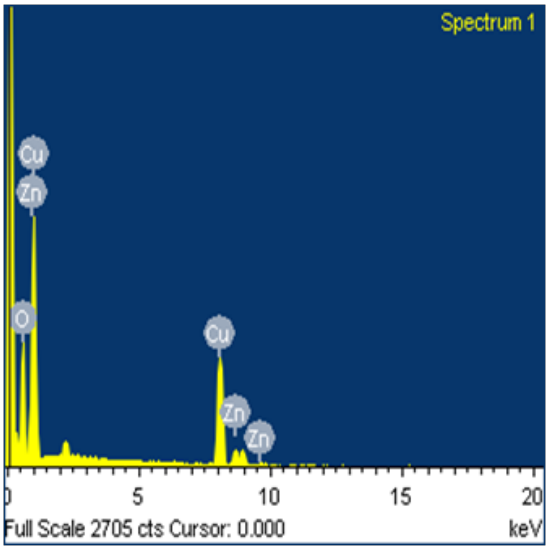

Fig. 4: Shows the EDAX analysis of Zn doped CuO nanoparticles

O elements, whereas no additional peaks were detected, which means that the as-prepared powder is exempted from impurities that arises from the starting precursors. The atomic percentage of Zn, Cu and O elements present in the as-present powder are 62.65, 32.74, 4.61% mass respectively. The results are shown in Table 4.

4. Conclusion:

Copper oxide nanoparticles were successfully synthesized by chemical precipitation method. X-ray diffraction studies show that the particles are monoclinic in nature. The functional groups present in synthesized copper oxide nanoparticles have been confirmed by FTIR spectrum. SEM images shows that the formation of Zn doped CuO nano crystals were flaky in nature. The EDAX analysis exhibited clear peaks of only Zn, Cu, O elements, whereas no additional peaks were detected.

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