Synthesis and characterization of pure and Zn-doped copper oxide nanoparticles

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ABSTRACT

Copper oxide is an important p-type semiconductor with monoclinic structure. It is attracting the researcher's attention because of its low cost, excellent reactivity, high stability, industrial and commercial applications. In this research paper pure and Zn-doped copper oxide nanoparticles are synthesized by microwave assisted method. The synthesized pure and Zn-doped copper oxide nanoparticles have been characterized by using X-ray diffraction (XRD) and scanning electron microscopy (SEM). X-ray diffraction pattern confirmed the monoclinic structure of CuO nanoparticles. The average size of nanoparticles is recorded 12 nm for pure CuO and 14 nm for Zn-doped CuO.

***Keywords:-* CuO, Nanoparticles, X-ray diffraction(XRD), scanning electron microscopy(SEM)**

I. INTRODUCTION

Recently, Nanotechnology has attracted many researchers from different areas like physics, chemistry, material sciences, biotechnology, engineering and medicine [1]. In nanotechnology, controlling morphology, structure and composition of materials with in the dimension of nanometers to micrometers have been a great challenge from the last few year for scientists [2]. Nanomaterials have interesting application in many areas [3].

Among all the transition metal, we investigated copper oxide nanoparticles which have importance for both technical as well as fundamental applications in various fields such as ceramic resistors, gas sensors, magnetic storage media, near infrared tilters, photoconductive and photothermal applications [4,5]. CuO is an important p-type semiconductor with monoclinic structure and narrow band gap 1.2 eV which show many interesting properties such as photoconductive, photothermal and as an antibacterial agent [6].

There are several ways to synthesize pure, doped CuO nanoparticles, including physical, biological (green synthesis) and chemical methods [1,3]. However, the physical and biological methods suffer from various difficulties in controlling the thermal stability and the doping homogeneity in the final products. Chemical methods such as precipitation [3], sol-gel [7] and hydrothermal [2] have widely used methods to synthesize pure and doped copper oxide nanoparticles. These methods are high energy consuming and require longer reaction time. In this research paper microwave assisted method is used for the synthesis of nanoparticles as microwave method provide fast and energy efficient naoparticles synthesis. The prepared pure CuO, doped CuO nanoparticles characterized by using XRD, SEM techniques.

II. MATERIALS AND METHODS

II.1. CHEMICALS

All chemicals were purchased from Merck India which are used for research work. Copper (II) acetate monohydrate, zinc acetate dihydrate and sodium hydroxide (NaOH) pellets are used.

II. 2. SYNTHESIS PROCEDURE

In this paper, pure and zinc-doped CuO nanoparticles synthesized by microwave assisted method. Analytical reagent (AR) grade copper (II) acetate monohydrate and sodium hydroxide (NaOH) pellets as precursors and for doping, zinc acetate dihydrate are used. Undoped CuO and Zn-doped CuO nanoparticles were synthesized by following procedure. Initially 0.02 M solution was prepared by using copper (II) acetate monohydrade and NaOH pellets. For the Zn dopant, zinc acetate dihydrate has been added drop-wise individually to the above prepared solution. The prepared solutions were kept in the microwave oven operated with frequency 2.45 GHz and power 800W. Microwave irradiation is carried out till the solvent is evaporated completely. After the microwave processing, the prepared solution was cooled at room temperature. The completion time of reaction and color of the samples are noted at the end of reaction. Obtained precipitate centrifuge for 15 minutes, then washed with distilled water and ethanol for several times to remove impurities and finally obtained precipitate was dried in an oven at 60^0C for 24 h. The prepared samples have been characterized through X-ray diffraction (XRD), scanning electron microscopy (SEM).

II.3. CHARACTERIZATION

The synthesized pure and Zn-doped CuO nanoparticles studied by powder x-ray diffraction (XRD) technique with Cuk$_\alpha$ radiation (λ = 1.54056) in the 2θ range of 20^0-80^0 at room temperature. Scanning electron microscopy (SEM) done for the morphology study of prepared pure and Zn-doped CuO nanoparticles.

III. RESULTS AND DISSCUSSIONS

III. 1. Structural analysis: X-ray diffraction

The characteristics X-ray diffraction patterns of pure and Zn-doped CuO nanoparticles were recorded in the range of 2θ between 20^0-80^0 shown in "fig." 1 and 2.The obtained XRD diffraction peaks for pure and Zn-doped CuO nanoparticles located at 2θ = 32.25^0, 35.13^0, 38.04^0, 48.97^0, 53.41^0, 58.12^0, 61.03^0, 66.47^0, 68.30^0, 72.23^0 and 75.11^0 correspond to (110), (-111), (111), (-202), (020), (202), (-113), (-311), (220), (311) and (004) planes respectively. The standard crystallographic planes confirmed the formation of the CuO monoclinic phase which matches with the standard JCPDS. Therefore there is no clear change in the peak position as well as the peaks are found to be quite sharp and intense.

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The average crystallite size was calculated by measuring the full width at the half maximum (FWHM) by using Debye-Scherrer equation

$$D = \frac{0.9\lambda}{\beta \cos \theta}$$

Where D is the average crystallite size, λ is the wavelength of the incident X-ray beam (1.5418Å), **θ** is the Braggs diffraction angle and β is the peak width at half maximum (FWHM). The average crystallite sizes of pure and Zn-doped CuO samples were found to be in the range of 12-14 nm. This indicates that crystallite size of nanoparticles slightly increases with increasing the amount of Zn-content.

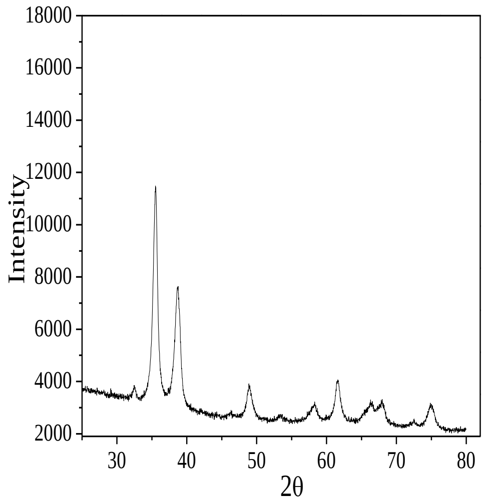

Fig.1

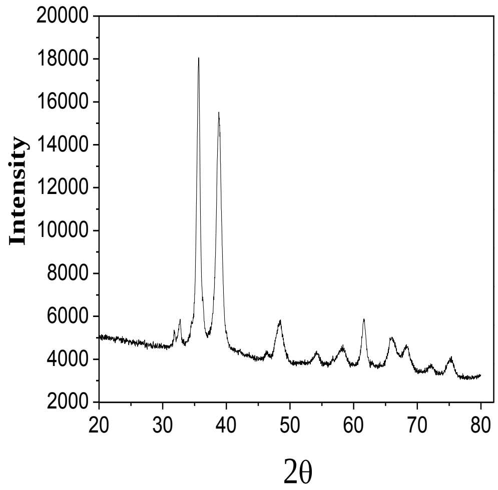

Fig.2

Fig.1. XRD pattern for Pure CuO nanoparticles 2. XRD pattern for Zn-doped CuO nanoparticles

III. 2. SEM analysis

The morphology of the powders of pure and Zn-doped CuO nanoparticles were investigated by scanning electron microscope (SEM). It is evident from SEM that pure CuO powder samples having sheet and flakes like structure and Zn-doped CuO powder samples having needle like structure through scanning electron microscope (SEM) “Fig.” 3(a) and (b) shows the SEM images of pure and Zn-doped CuO nanoparticles.

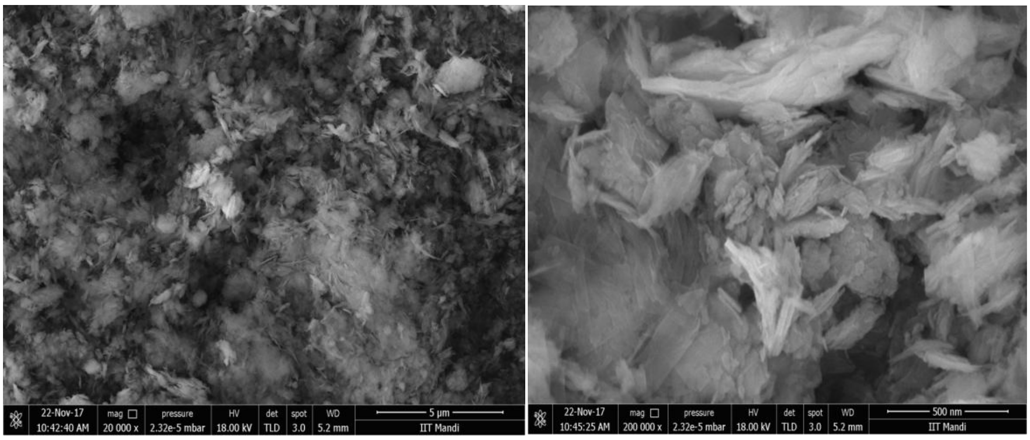

Fig. 3(a) SEM images for pure CuO nanoparticles

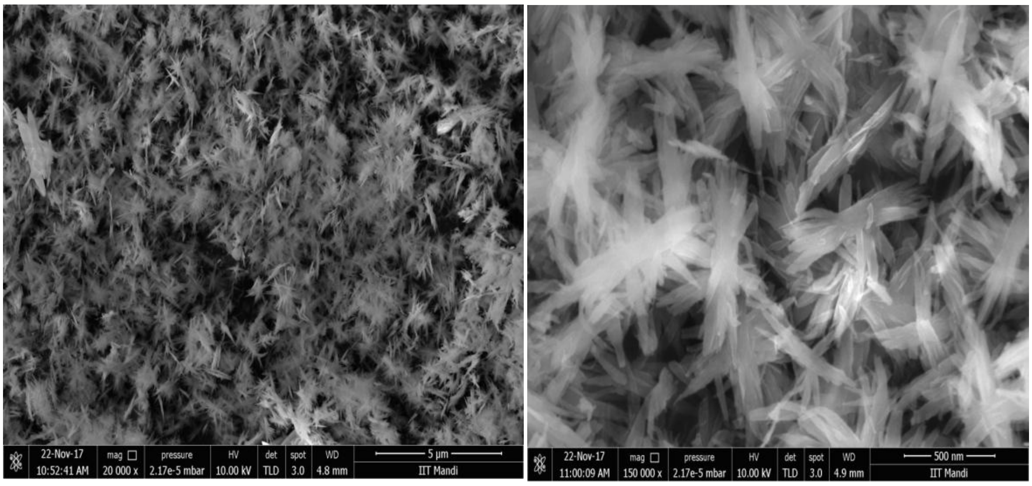

Fig. 3(b) SEM images for Zn-doped CuO nanoparticles

IV. CONCLUSION

Pure and Zn-doped CuO nanoparticles are successfully synthesized by microwave assisted method. XRD patterns confirmed the formation of the monoclinic phase of nanoparticles. The average crystallite size of pure CuO nanoparticles is 12nm and for Zn-doped CuO nanoparticles is in the range of 14nm.This results shows that, the crystallite size of nanoparticles increases with the content of doping. Scanning electron microscope (SEM) analysis shows the formation of various morphologies.

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