Structural analysis of Cu doped MgO nanoparticles using Co-precipitation Method

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***Abstract*— The application of nanoscale materials usually ranging from 1 to 100 nanometers is an emerging area of nanoscience and nanotechnology. Since MgO nanoparticles have unique optical, thermal and structural properties, it has many applications such as electronics, catalysis, ceramics and cement. In the present work we focused on the synthesis of MgO and Cu doped MgO nanoparticles using Co- precipitation method. From the XRD analysis, the crystalline size of MgO and Cu doped MgO nanoparticles are calculated by Debye Scherrer's formula and found to be 20.27nm 30.67nm respectively. The morphology of prepared nanocrystals is studied by Scanning Electron Microscope (SEM).**

***Key words*— Synthesis, XRD, SEM.**

I. INTRODUCTION

In recent years, metal and semiconductor nano particles received considerable attention as active components in a wide variety of basic research and technological applications due to their improved optical, electrical and magnetic properties compared to their bulk counter-parts [1]. MgO is an important material which has many applications in catalysis, toxic waste remediation, paint, superconducting products and anti-bacterial activities [2]. The compound MgO have boiling and melting points as 3600ºC and 2852ºC. These oxide materials can be synthesized by different methods such as Solution Combustion, Chemical Precipitation, Sol-Gel, Hydrothermal, Solvothermal, Microwave Assisted Sol-Gel, Green synthesis. In these methods, Co-precipitation is one of the best methods to synthesis nanoparticles without agglomeration in the yield. In this present paper, MgO and Cu doped MgO nanoparticles are prepared by Co-precipitation method. The samples were synthesized under standard laboratory conditions in clean room and analyzed using such as X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM).

II. EXPERIMENTAL PROCEDURE

Synthesis of MgO Nanoparticles

To prepare MgO nanoparticles, 100mL of 0.4 M KOH solution is added drop-wise into a solution containing 100mL of 0.6 M Magnesium Chloride solution under constant stirring. Then the resulting solution is kept at room temperature for three hours under constant stirring. A white precipitate is formed. It is washed several times with distilled water and this precipitate dried at 100^0C in an oven for 3 hours. The obtained samples are calcinated in at 300^0C for 2 hours to get MgO nano particles.

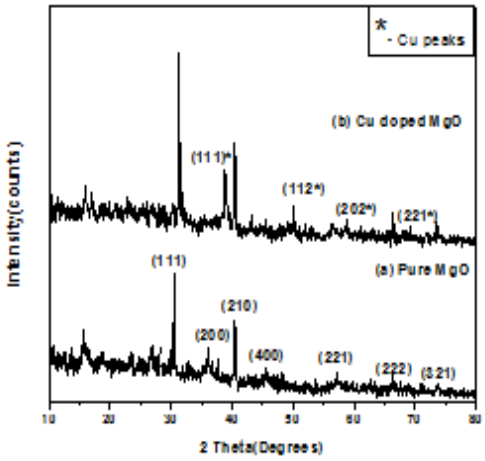
Synthesis of Cu doped MgO nanoparticles

To prepare Cu doped MgO nanoparticles, 100 mL of (0.4M)KOH is added drop-wise into a mixture solution of 100 mL of (0.6 M) Magnesium Chloride and 100 mL of (0.01M) Copper Chloride under constant stirring. Then the resulting solution was kept at room temperature for three hours under constant stirring. Obtained bluish grean precipitate is washed several times with distilled water and dried at 100^0C in an oven for 3 hours. Finally the precalcinated in at 300^0C for 2 hours to get Cu doped MgO nano particles.

III. RESULTS AND DISCUSSION

X-ray Diffraction

X-ray diffraction is a versatile, non-destructive analytical method for identification and quantitative determination of a various crystalline forms known as phases of compound present in powder and solid samples. In **Fig-1(a)**, Seven major diffraction peaks are seen at 30.361, 36.1268, 40.49, 45.59, 57.06, 66.356 and 73.627 corresponding to lattice planes (111), (200), (210), (400), (221), (222) and (620) according to the data base in JCPDS card (No-761-363). It reveals that the resultant nanoparticles are pure MgO with a cubic structure. The estimated value of lattice parameters a=b=c=0.4839 nm which are in good agreement with JCPDS data of MgO. In **Fig-1(b)**, four major diffraction peaks are seen at 38.762, 50.037, 58.30 and 69.149 corresponding to the lattice planes from (111), (112), (202) and (221) planes respectively according to CuO JCPDS data of CuO (NO-895-895)). It indicates the presence of Cu in the MgO nano particles. Similar results have been reported by the author Asha Radhakrishnan [3].



. Figure1. XRD Spectra of MgO nanoparticles.

The average crystallite size of the nanoparticles is determine by using the Debye - Scherrer equation [4]

$$D = K\lambda/\beta \cos\theta \qquad (1)$$

The dislocation density is used to determine the amount of defects presents the grown samples which are determined using the following equation [5].

$$\delta = 1/D^2 \qquad (2)$$

The lattice strain (ε) has been determined by using the tangent formula [6]

$$\varepsilon = \beta/(4\tan\theta) \qquad (3)$$

Where D is the crystallite size, K is the typical value (0.9), λ is the wavelength of incident beam, β is the broadening half of its maximum intensity (FWHM) and θ is the Bragg's angle. The average crystallite size was calculated using Debye Scherrer equation 20.27 nm for un doped MgO and 30.67 nm for Cu doped MgO nanoparticles. The crystallite size of Cu doped MgO is higher than pure MgO nanoparticles. The author Ruby Chauhan has reported that the crystalline size of ZnO nanoparticles increases after doping of Cu [7]. The obtained value of dislocation density (δ) of Cu doped MgO is lesser than pure MgO nanoparticles. The lattice strain (*ε*) of Cu doped MgO nanoparticles is reduced. It explains the grain can grew much easier due to the incorporation of Cu dopant.

Crystallite Size, Dislocation Density and Lattice Strain for pure and Cu doped MgO nanoparticles.

Samples	Crystallite Size (nm)	δ (× 10^{15}) (lines/m^2)	*ε*
Pure MgO	20.27	2.433	0.006797
Cu doped MgO	30.67	1.063	0.004997

Scanning Electron Microscope

Fig. 2 (a) shows a cubic shape of MgO nanoparticle which is consistent with from XRD results of MgO. Sometimes the surface properties of MgO are influenced from the incorporation of dopant. Especially the amount and kind of dopant can play an important role on the surface properties. In fig (b), the Cu doped MgO nanoparticles are agglomerated. This may be due to the defects created by Cu doping. As the dopant concentration increases, the agglomeration of particles takes place and hence particle size increases as compared to the pure MgO nano particles [8].

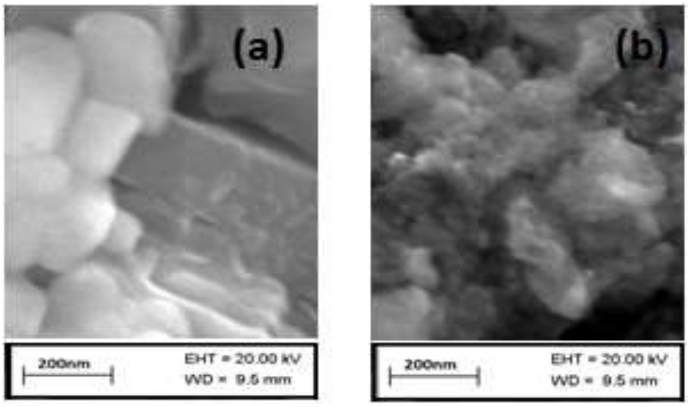


Fig 2. SEM image of pure MgO and Cu doped MgO nanoparticles

IV. CONCLUSIONS

The X-ray diffraction analysis of the nanoparticles confirmed crystalline nature of the powder. The prepared sample particle size was below 100 nm and it was established from X-ray diffraction. From this study the size of the particle, Dislocation density and strain is determined. The grain sizes of the samples are in the range between 20.27nm to 30.67 nm. SEM analysis confirmed the morphology of cubic structure of MgO nano particles.

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