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Optical Analysis of Cu Doped Mg Nanoparticles Using Co-Precipitation Method

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Abstract*: Metal oxide nanomaterials with high surface area have attracted considerable interest for scientific research due to their potential applications in the field of nano electronics, optoelectronics and sensing devices. Magnesium oxide nanoparticles are odorless and non-toxic. They possess high hardness, high purity and a high melting point. In Present work we focused on synthesis of MgO and Cu doped MgO Nanoparticles by Co-Precipitation method. The X-ray diffraction analysis indicates that the synthesized MgO nanoparticle has a cubic structure and the average crystalline size of pure MgO and Cu doped MgO has been found to be 20 nm and 26.9938nm respectively. From the UV analysis the optical band gap of pure MgO and Cu doped MgO nano particle is found to be in the range from 3.3eV and 3.1eV.
Keywords*: Synthesis, Nanoparticles, MgO, XRD, UV.

I. INTRODUCTION

These Nanomaterials with diameters of less than 100 nm are being used in a number of applications across multiple domains such as biology, physics, chemistry, cosmetics, optical components, polymer science, pharmaceutical drug manufacture, toxicology, and mechanical engineering. In particular, magnesium oxide (MgO), a versatile oxide material with assorted properties finds extensive applications in catalysis, ceramics, toxic waste remediation, and as an additive in paint and superconductor products [1]. Magnesium oxide nanoparticles appear in a white powder form. 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 subjected to X-ray Diffraction (XRD) and UV Spectroscopy (UV) studies.

II. EXPERIMENTAL PROCEDURE

A. Synthesis of MgO Nanoparticle

To prepare MgO nanoparticles, 100mL of 0.4M KOH solution is added drop-wise into a solution containing 100mL of 0.6M 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.

B. Synthesis of Cu doped MgO nanoparticles

Toprepare Cu doped MgO nanoparticles, 100mL of (0.4M)KOH is added drop-wise into a mixture solution of 100 mL of (0.6M) Magnesium Chloride and 100mL 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

A. 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

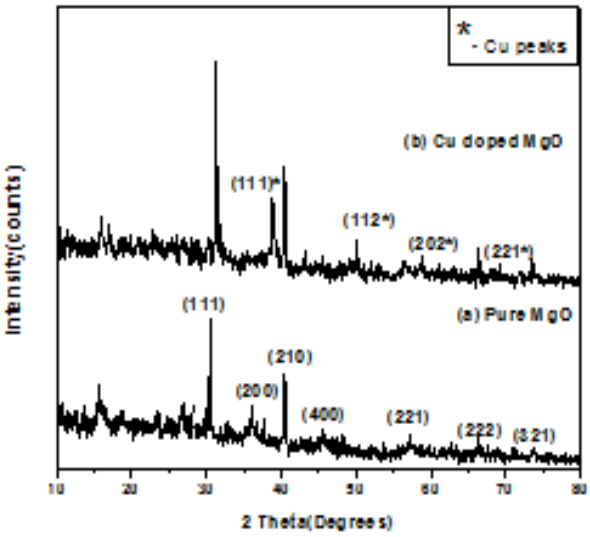

Figure1. XRD Spectra of MgO nanoparticles.

In Fig-1(a), Seven major diffraction peaks are seen at 30.361°, 36.126°, 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[2].

The average crystallite size of the nanoparticles is determined by using the Debye - Scherrer equation [3]

$$D = K\lambda/\beta \cos\theta \text{ --------- (1)}$$

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 is calculated using Debye Scherrer equation. It has been found to be 20.27 nm for undoped 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 **[4].**

B. UV Analysis

The optical properties of the MgO and Cu doped MgO NanoParticles remain calculated in part by means of the UV–Visible absorption spectra in the wavelength range between the 100–900 nm. The energy band gap is determined by using the relationship:

$$\alpha = A (h\nu - Eg)^{n} \text{-------(4)}$$

where$h\nu$= Photon energy, α= Absorption coefficient ($\alpha = 4\pi k/\lambda$; k is the absorption index or absorbance, λ is wavelength in nm), Eg =Energy band gap, A=constant , n=1/2 for allowed direct band gap. Exponent n depends on the type of transition and it may have values 1/2, 2, 3/2 and 3 corresponding to the allowed direct, allowed indirect, forbidden direct and forbidden indirect transitions respectively [5]. Figure 2 (a) and Figure 2(b) shows the direct band gap of $(\alpha h\nu)^2$ versus photon energy ($h\nu$) of the pure MgO and Cu doped MgO nanoparticles.

The optical band gap of doped and undoped MgO nanoparticles has been studied. The band gap of pure MgO is 3.3 eV**[6]**and band gap of (0.01M) Cu doped MgO is 3.1eV, which are less than that of pure MgO. The similar results have been reported by the authorRuby chauhan**[4]** for Cu doped ZnO. The band gap of pure MgO is decreased on doping with Cu. We observe that the absorption band edge of MgO is red shift upon Cu doping. The effect of the quantum confinement on impurity depends upon the size of the host crystal. As the size of the host crystal decreases, the degree of confinement and its effect increases **[7]**.

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Table1.
The crystalline size and direct band gap of MgO and Cu doped MgO.

Samples	crystalline Size (nm)	Direct Band Gap (eV)	Indirect Band Gap (eV)
Pure MgO	20.27	3.3	2.25
Doped MgO	30.67	3.1	2.23

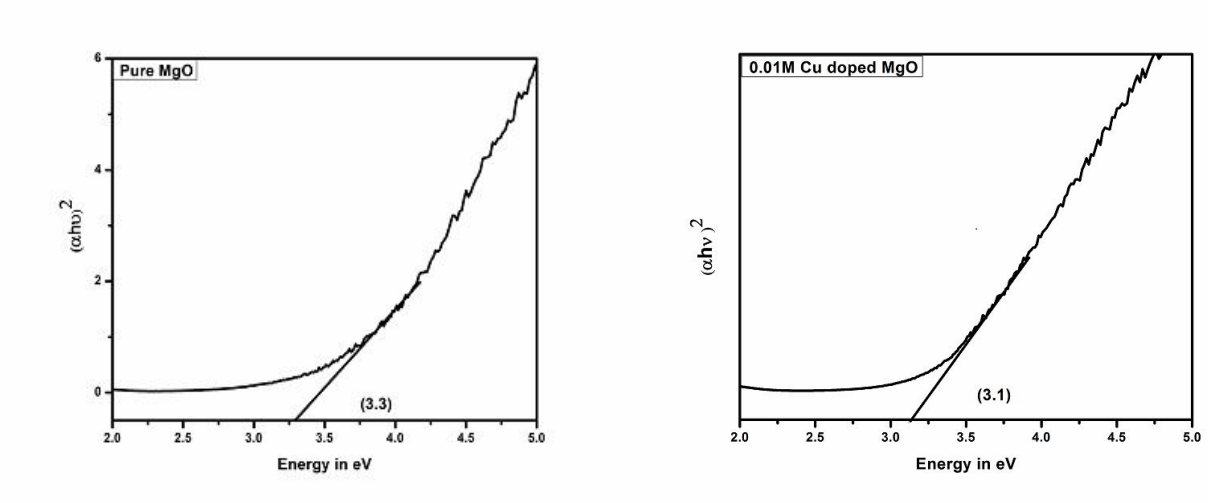

Figure 2. (a) Direct bandgap for pure MgO and Cu doped MgO

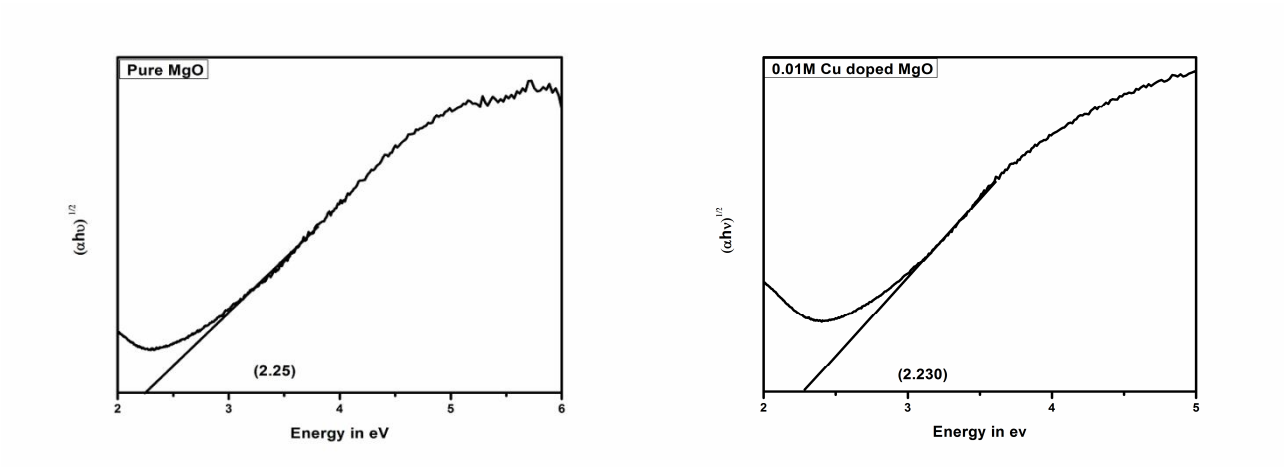

Figure 2. (b) Indirect bandgap for pure MgO and Cu doped MgO

IV. CONCLUSIONS

The X-ray diffraction analysis of the nanoparticles is confirmed crystalline nature of the powder. The grain sizes of the samples are in the range between 20.27nm to 30.67nm and its below 100nm. In optical analysis, that the absorption band edge of MgO is red shift upon Cu doping. The direct band gap of MgO nanoparticles is higher as compared to indirect band gap which confirms that the materials are crystalline in nature.

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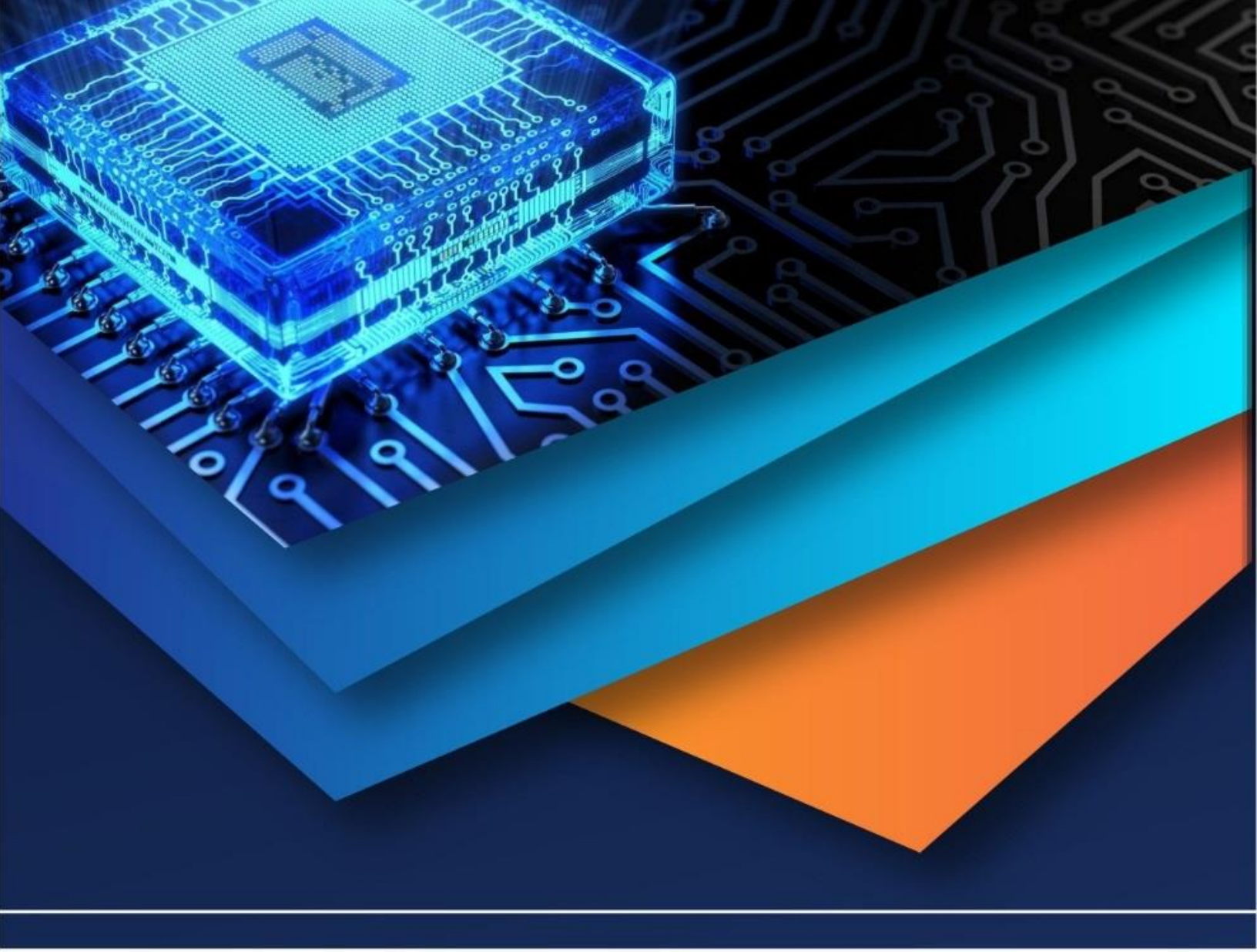

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