Effects on Structural, Functional groups and Photo Luminance Properties of Copper Doped Zinc Oxide Nanoparticles

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Abstract Present study we reported the structural, optical and functional group study of copper-doped zinc oxide nanoparticles (NPs) synthesized by chemical co-precipitation method. In this study doping concentration of copper (0.2, 0.4, 0.6) was incorporated in zinc oxide. All the synthesized samples were characterized by X-ray diffraction (XRD) as well as Fourier transform infrared (FTIR) and studied the photo luminance (PL) property. XRD study confirms the structural and purity of ZnO and Cu doped ZnO nanoparticles. The average grain size of pure ZnO was calculated by Scherrer formula and it varied according to doping concentration from 25.10 to 20.26 nm. The average grain size of pure ZnO was decreased for Cu-doped samples. The presence of functional groups and chemical bonding were confirmed by FTIR. Due to the doping concentration of copper the structural, functional group and photo luminance properties of ZnO was changed drastically.

1. Introduction
The properties of bulk materials changed drastically when it reduced in nano size i.e. $10^{-9}$ m and it used to distinct applications. The metal oxide nanomaterial’s are very much interesting for the scientific community due its extra ordinary properties and application. Among the various metal oxide nanoparticles zinc oxide (ZnO) proves its more impact due to potential applications in industry. ZnO nanoparticles have hexagonal wurtzite structure which is favors the interesting piezoelectric properties. ZnO belongs to II-VI semiconductors (n-type) family with a direct wide band gap (3.37eV) and large exciton binding energy (60meV) at room temperature. Due to these properties, ZnO proves its importance and applicability for optoelectronic devices [1-2]. As well as ZnO nanoparticles applicable for ultraviolet (UV) light-emitters [3], cosmetics and biomaterials, field-effect transistors, solar photo electrochemical cells [4-8]. The optical and electronic properties of semiconductor nanocrystals can easily tuned, thus it has been extensively investigated for the past few decades. Specifically, transition-metal doped semiconductor nanocrystals have attracted a lot of attention in the context of their technologically interesting fluorescence properties [6-11].
In present investigation we have been reported the Cu doped ZnO nanoparticles synthesized via chemical co-precipitation method. The synthesized nano composite studied by various characterization techniques and explored its properties.

2. Experimental
All chemicals used in present study were analytical reagent grade and used as purchased. Zinc acetate (Zn(CH₃COO)₂·2H₂O), copper chloride (CuCl₂), and precursor sodium hydroxide (NaOH), was procured from scientific fisher, India and used for synthesis the pure ZnO and Cu doped ZnO nanoparticles. Pure ZnO prepared by chemical co-precipitation method using zinc acetate (1M) and sodium hydroxide (2M) and Cu doping Zn₁₋ₓCxO (x=0.0, 0.2, 0.3, 0.4) concentrations was used.

3. Result and discussion
3.1 Structural study
Structural properties of pure and Cu doped ZnO studied by X-ray diffraction spectroscopy (XRD) and shown in fig. 1. XRD study shows all the characteristics peaks respect to pure and Cu doped ZnO at an angle 2θ i.e., at 32.04°, 34.67°, 36.51°, 47.81°, 56.91°, 63.12° and 68.29° which correspond to the Miller indices (1 0 0), (0 0 2), (1 0 1), (1 0 2), (1 1 0), (1 0 3) and (2 2 0) respectively [12,13]. The observed data of pure and Cu doped ZnO shows hexagonal wurtzite phase with P63mc(186) group and clearly matched with JCPDS card no. (96-900-4181).

![XRD pattern spectra of samples](image)

The average grain size of all the prepared various with (25.10 to 20.26 nm) was calculated by using Scherer Formula. The average grain size reduced by doping ZnO with Cu is mainly due to the alteration in the host ZnO lattice [14,15].
3.2 FT-IR analysis
Functional group study and vibration analysis of prepared sample was carried out by FTIR spectroscopy shown in fig. 2. The wave numbers and corresponding peaks with its reasons are tabulated in the following table [16, 17]. The FTIR spectrum shows the all functional groups corresponding to metal and it confirms the prepared sample in desired form.

![FTIR spectra of samples with concentration](image)

**Fig. 2.** FTIR spectra of samples with concentration

| Wave number (cm\(^{-1}\)) | Characteristic Peaks |
|---------------------------|----------------------|
| 500 cm\(^{-1}\) and 600 cm\(^{-1}\) | vibrations of metal oxides |
| 1400 cm\(^{-1}\) – 1800 cm\(^{-1}\) | \(\text{C}=\text{C}\) and \(\text{C}=\text{O}\) vibrations which may be due to organic compounds |
| 2300 cm\(^{-1}\) and 2400 cm\(^{-1}\) | due to \(\text{C}≡\text{C}\) bond |
| 3500 cm\(^{-1}\) and 4000 cm\(^{-1}\) | stretching of hydroxyl groups that is due to O-H or N-H or C-H vibrations |

3.3 Photo luminescence (PL) analysis
Photoluminescence (PL) technique was used to study the crystalline quality and doping effect of Cu in ZnO for optical properties. In PL spectrum one emanation peak reveals in visible region (550 nm) shown in fig.3. In PL spectrum the dominating peak was observed at the visible light region. The intensity of the visible region peaks of doped samples was found to increase by increasing Cu content.
The originating peak in visible region is become improved due to the change of size of dopant and the host material which produced defects such as oxygen vacancies, and zinc vacancies [18,19].

4. Conclusion
In present study we have successfully prepared the pure and Cu doped ZnO system by co-precipitation method. The structural study shows the prepared samples hexagonal wurtzite phase with P63mc (186) group and grain size various with (25.10 to 20.26 nm) by doping concentration of Cu ions. Functional group study shows the all characteristics peaks corresponding to ZnO and Cu doped ZnO. The Photoluminescence study confirms the peak at 550 nm in visible region.

5. References
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