# A Study of ZnO-CdS Nanoparticles Synthesis and its Characterization Technique

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## Abstract:

In the present research paper work has been presented on the synthesis and characterization technique used for getting the information about the prepared nano-composites of ZnO-CdS sample. The impact of annealing process on the properties of orchestrated nanocomposite has been examined. For this, a piece of the blended sample was made to go through the process of annealing at 245°C, termed as annealed sample of ZnO-CdS. ZnO-CdS composite can be blended by substance co-precipitation technique, aqueous thermal strategy and solvo-thermal strategy and so on. The primary, optical and electrical way of behaving of ZnO-CdS has been found to rely upon the molar proportions of zinc and cadmium pre-cursors. The toughening system of annealing mechanism altogether changes the properties of ZnO-CdS nanocomposite. CdS happens in nature with three unique crystal structures specifically as hexagonal wurtzite form, cubical zinc blende form and rock salt form. The variation in the values for band gap of CdS can be stated as: Varying from 2.41 eV (In Bulk mode) to 2.58 eV, 2.75 eV, 3.56 eV and 3.84 eV relating to 9.1 nm, 5.1 nm, 2.1 nm and 0.8 nm molecule sizes. ZnO-CdS nanocomposites were synthesized by using the technique of chemical co-precipitation for synthesis of nano-particles. Four samples of 100 mL aqueous sol. of Zinc acetate ($Zn(CH_3COO)_2$), Sodium hydroxide (NaOH), Cadmium acetate ($Cd(CH_3COO)_2$) and Sodium sulphide ($Na_2S$) were prepared in isolation by method of uniform stirring.

In order to get the information about the effect of annealing on the properties of samples of nano-composites of ZnO-CdS, a comparison has been performed for both the samples ZnO-CdS (without annealing) and ZnO-CdS (with annealing) by using various methods. The X-ray diffraction (XRD) result showed that the samples of ZnO and CdS are showing hexagonal and cubic stage separately in both the examples. Similarly, there is variation in the typical crystallite size of sample prepared with and without annealing for ZnO-CdS samples. The absorption peak for ZnO-CdS sample prepared with and without annealing for ZnO-CdS moved towards lower side as contrast with the samples of annealed ZnO-CdS. More assemblage and arrangement of large sized particles has been noticed for annealed ZnO-CdS nano-composites.

**Keywords**: annealing, nanocomposite, optical, bulk, photograph, nano-particles, crystallite, assemblage

# 1. Introduction:

Cadmium sulphide (CdS) is an II-IV semiconductor inorganic compound having yellow tone. Mass CdS has hexagonal wurtzite type structure having dissolving point at 1600°C and band gap energy (Eg = 2.42 eV at room temperature. While CdS happens in nature with three unique crystal structures specifically as hexagonal wurtzite form, cubical zinc blende form and rock salt form. Hexagonal wurtzite stage happens just in bulk stage while cubical zinc blende design and rock salt form exists in the nano-crystalline state. The variation in the values for band gap of CdS can be stated as: Varying from 2.41 eV (In Bulk mode) to 2.58 eV, 2.75 eV, 3.56 eV and 3.84 eV relating to 9.1 nm, 5.1 nm, 2.1 nm and 0.8 nm molecule sizes. ZnO is a widely used band gap semiconductor whose photograph reaction is limited to bright UV region only. The Ultra violet spectrum region is just 4% of the complete sun based spectrum range. Low band gap material like CdS is composited with ZnO to improve its photograph reaction for apparent regions in the visible part of the spectrum also. ZnO-CdS nanocomposites are explored for applications in optical and electronic gadgets, photo-catalysis and solar based photo cells.

ZnO-CdS composite can be blended by substance co-precipitation technique, aqueous thermal strategy and solvo-thermal strategy and so on. The primary, optical and electrical way of behaving of ZnO-CdS has been found to rely upon the molar proportions of zinc and cadmium pre-cursors. The toughening system of annealing mechanism altogether changes the properties of ZnO-CdS nanocomposite. In the present paper, we have combined ZnO-CdS as nanocomposite and explored the impact of tempering/annealing cycle on the observed properties of blended nanocomposite material.

## 1. Experimental Design and technique for synthesis and characterization of ZnCd nano-composites

### 1.1 Required Materials/apparatus:

a) Zinc Acetate di-hydrate having chemical formula as $Zn(CH_3COO)_2.2H_2O$,
b) Sodium Hydroxide pellets having chemical formula as NaOH,
c) Cadmium Acetate dehydrate having chemical formula as $Cd(CH_3COO)_2.2H_2O$ and
d) Sodium Sulphide fused flakes having chemical formula as $Na_2S$

Above written four materials were utilized for the preparation of ZnO-CdS nano-composite particles. Doubly distilled water solution (written as DDWS) was used for the preparation of nanoparticles required. All of the above the reactants were taken in their present available form and used in the same form without any voluntary modification in them. All the said reactions for the synthesis of nano-composites take place at the normal values of room temperature.

### 1.2 Preparation of Zn-Cd nano-composites

ZnO-CdS nanocomposites were synthesized by using the technique of chemical co-precipitation for synthesis of nano-particles. Four samples of 100 mL aqueous sol. of Zinc acetate ($Zn(CH_3COO)_2$), Sodium hydroxide (NaOH), Cadmium acetate ($Cd(CH_3COO)_2$) and Sodium sulphide ($Na_2S$) were prepared in isolation by method of uniform stirring. Solution of NaOH was added to the solution of zinc acetate drop by drop at

uniform stirring done at constant rate. The transparent solution obtained by doing constant stirring changes into white color solution. After span of nearly 01 hr. of constant stirring, cadmium acetate solution was poured in to it with again uniform rate of stirring performed during this addition process. After one half of the hour of uniform rate of stirring done, sodium sulphide solution was further add to this obtained solution. As a result of this uniform stirring, the appearance of resultant solution becomes yellow colored solution. Again. This yellow colored solution was stirred for nearly 02 hrs. time duration at uniform rate of stirring and the resultant solution becomes gel like and looks as if it is being transformed into thick/dense precipitate form. The thick precipitate obtained was maintained at still position for duration of one day i.e. 24 hrs. The resultant thick precipitate of ZnO-CdS nanocomposite was cleaned by washing with double distilled water and then it is filtered off. After the washing and cleaning of the precipitate solution, it is allowed to dry at the normal room temperature. After the completion of drying process for the precipitate, it is accumulated and with the help of motor pestle, this is converted into fine power. Thus, the prepared sample is termed as ZnO-CdS nanocomposite.

### 1.2.1 Characterization of synthesized ZnO-Cd nanocomposites:

For investigation of the optical properties of synthesized ZnO-CdS Nano-composites samples, Ultra Violet-visible method for characterization of these nanocomposites was used. Further, for the investigation purpose of the structure properties of the ZnO-CdS Nano-composites samples was performed by using X-Ray method. It is functional for the diffraction phenomena in the range of 2θ (where θ is taken as diffraction angle)i.e. range of angle is taken in the order of 20° – 80° at 40 kV potential and during this process scanning was done at angle variation for every 0.02°. For the morphological mode of study, the synthesized samples characterized by the use of FE- SEM technique (Field Emission - Scanning Electron Microscope.

## 2. Results and discussion:

### 2.1 Investigation of ZnO-CdS structure using X-Ray diffraction:

In the fig. 1 shown below, X-Ray Diffraction patterns of the prepared samples of ZnO-CdS Nano-composites is shown for the observation and analyzation purpose of the same. Here two different readings in the form of graphical curve is shown in which one curve is showing the readings coming from simple ZnO-CdS sample while the other sample shown related to the readings coming from ZnO-CdS (Annealed sample). The X-Ray Diffraction peaks are arising for various angle of diffraction occurring across them, taken as 2θ. Angle of diffraction is confirmed in these two samples of ZnO taken and found to be equal to 30.50°, 33.32°, 33.19°, 46.75° and 55.48° confirming its hexagonal phase for theses samples. While in case of CdS, the angle of diffraction is confirmed in the given two samples of CdS taken and is found to be equal to 2θ having value as 26.54°, 42.32° and 51.19° confirming the existence of cubic phase of CdS in the two samples taken for the experiment.

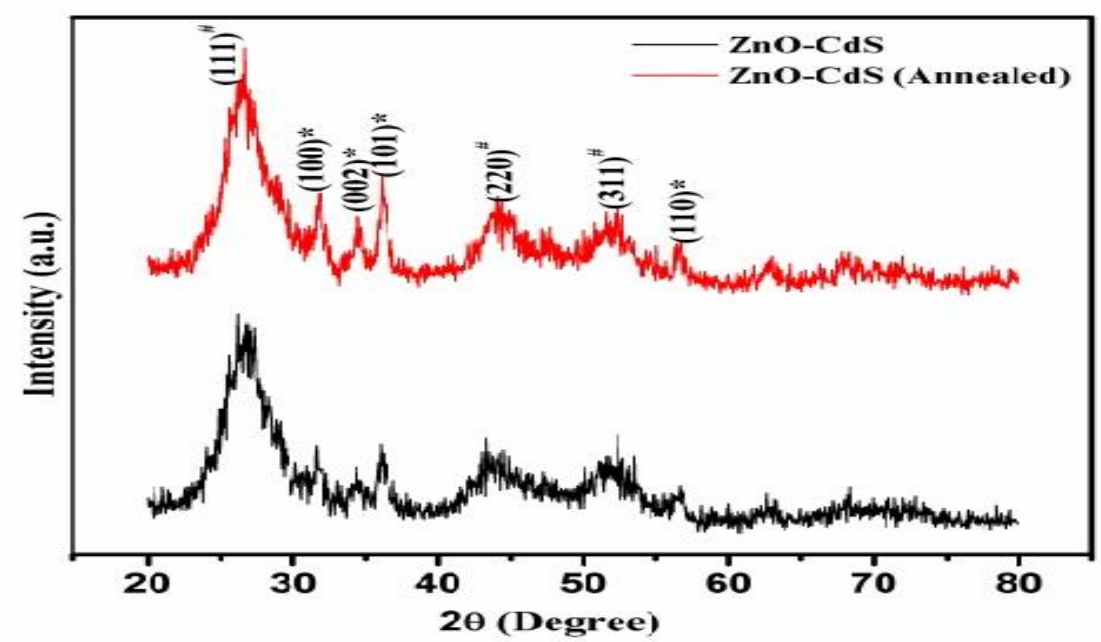


**Fig.1 Showing diffraction peaks obtained for samples of ZnO-CdS samples**

In the fig.1 shown above, the peaks are designated with the symbols taken as *and # which are corresponding to the diffraction peaks for the samples of ZnO and CdS nanoparticles respectively. There is absence of any further peak in addition to the already discussed peaks in X Ray Diffraction diagram obtained for ZnO and CdS, it confirms that we have successfully synthesize nano-composites for ZnO-CdS samples. By using the Scherrer formula for the calculation of size of crystals taken as sample, we calculated the mean value for size obtained for the crystal sample taken for ZnO-CdS and the crystal planes taken under consideration for the said purpose are – [1,1,1], [2,0,0] and [3,1,1] for peaks corresponding to # and the crystal planes of [1,0,0], [0,0,2] and [1.0,1] corresponding to the peaks for * diffraction peak. During the calculation using scherrer formula, constant value is taken for k equal to 0.90, X Ray used for the purpose of diffraction in XRD is having wavelength equal to 0.152 nm. Intensity of radiation for diffraction peak is shown by symbol β showing the value for FW at HM i.e Full width for radiation intensity obtained at value of half maxima, Angle of diffraction observed during the above diffraction of X-Rays by crystal planes is taken as 2θ, popularly known as Bragg's Angle because it satisfies the condition imposed by Bragg's Law i.e.

$$2\,d\,\sin\theta = n\,\lambda$$

Where, d is distance between inter atomic lattice plane

θ is the angle of diffraction

n is the order of diffraction

$\lambda$ is the wavelength used for diffraction

Analytical Solution:

On mathematical analysis for the mean value of size of the ZnO-CdS , the valuescomes out to be equal to 14.2 nm and 16.9 nm for the samples of simple and annealed ZnO-CdS respectively . It can be analyzed from the calculated values of crystal sizes that the size of ZnO-CdS gets enhanced after the annealing process.

## 2.2 Investigation of Optical properties of ZnO-Cd nano-composite using UV spectroscopy:

To break down the optical properties of prepared ZnO-CdS nanoparticles , we have performed Ultra Violet Visible spectroscopy ( popularly called as UV-Vis spectroscopy technique) and analyzed the prepared sample of the nano-composite ZnO-CdS both simple and annealed. The optical retention spectra of samples of ZnO-CdS nano-composites are displayed in Fig. 2 shown below. The most extreme absorption peak value exists at 403.5 nm in case of annealed sample of ZnO-CdS while the same in case of simple sample of ZnO-CdS nano-composite comes out to be at a lower value as compare to annealed sample and this low value obtained from peak is just 398.98 nm. This variation in the observed value for the absorption peak is because of the phenomena of confinement due to quantum effect treatment of the given sample. Thus, it can be summarized here from the above decrease in size of prepared nano-composites that there is always tendency of shifting of peak value for absorption spectra if the size of prepared nanoparticles is brought close to the value of Bohr's radius value.

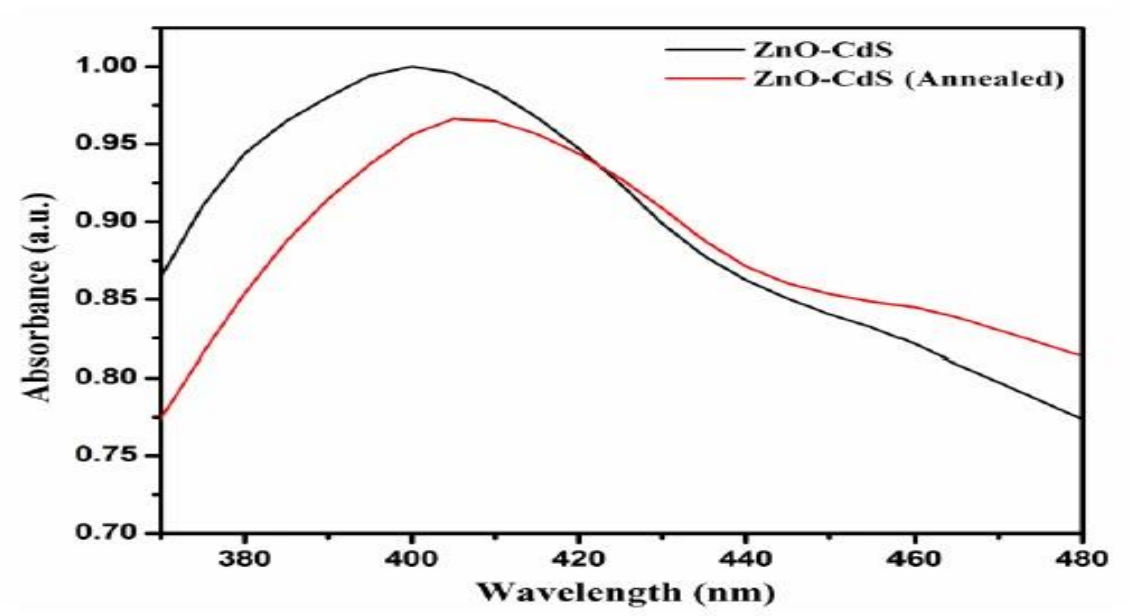


**Fig. 2 UV-visible spectroscopy for sample showing shift in peak value for samples prepared**

## 2.3 Investigation of surface topology using scanning electron microscope (SEM):

In the Fig. 3 shown below the spectra obtained is given by Field Emission Scanning Electron Microscopy technique used for the prepared samples of simple ZnO-CdS nano-composite is shown as:

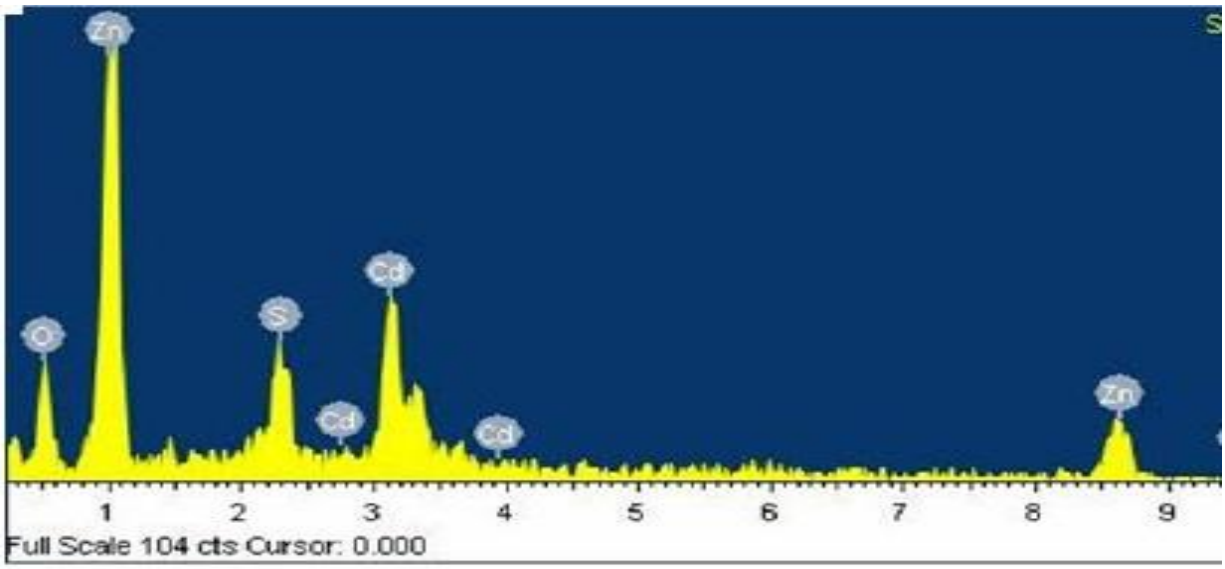


**Fig. 3 Showing peaks of given sample of ZnO-CdS by EDS spectra**

In the Fig. 4 shown below the spectra obtained is given by Field Emission Scanning Electron Microscopy technique used for the prepared samples of annealed ZnO-CdS nano-composite is shown as:

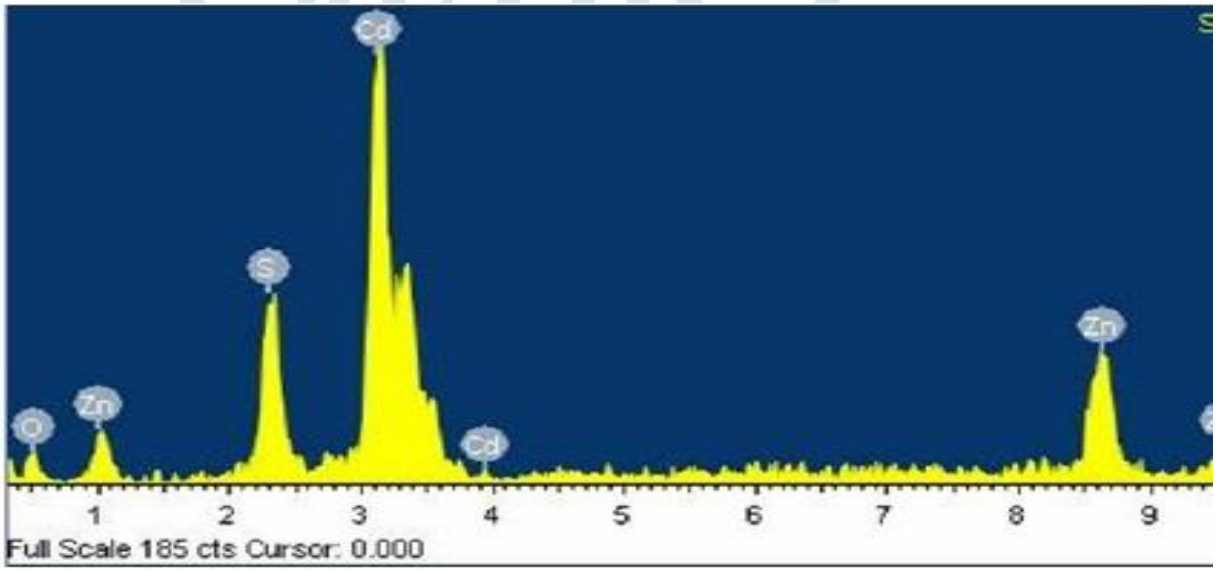


**Fig. 4 Showing peaks of given sample of annealed ZnO-CdS by EDS spectra**

In the above two graphs obtained as figure 3 and 4, various peaks obtained in the spectral analysis. Are responsible for confirming the existence of Zn, O, Cd and S in the prepared sample of nano- composite ZnO-CdS nanoparticles.

## 3. Conclusion:

Sample of ZnO-CdS nano-composite used in the present research work has been prepared by utilizing the technique of chemical co-precipitation. The comparative examination for the prepared two samples of nano-composites and this has been done with and without the help of annealing process. Sample of ZnO-CdS nano-composites which are annealed at nearly 245°C are showing size larger in size in comparison with the counterpart prepared samples of nano-composites ZnO-CdS, in the absence of annealing). Same result of larger assemblage for the annealed sample and shifting of peak is confirmed by the spectral images obtained in case of UV-Visible

spectroscopy. Again, the result of larger assemblage for the annealed sample is re-confirmed by the spectral images obtained in case of Field Effect – Scanning Electron Microscopy technique of spectroscopy. Thus, it is summarized here that by using the annealing method for sample of prepared nano-composites, we can easily change its properties.

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