DOI:10.26524/ijsth47

International Journal of Science, Technology and Humanities 3 (2015) 23-25

ISSN : 2394-7209
E-ISSN : 2394-7217

Available online at www.svmcugi.com

International Journal of Science, Technology and Humanities

Effect of Zinc concentration on the properties of CdS:Zn nanostructures prepared by Ultrasonic method

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Received: 27 August 2015: Received in revised form 26 September 2015; Accepted 8 October 2015

Abstract

This work focuses on investigating the effect of Zn concentration on the properties of CdS:Zn nanoparticles. In the typical synthesis, nanostructured CdS:Zn has been prepared using Cadmium nitrate, zinc nitrate, Na_2S, citric acid and ethanol as starting materials. The samples were prepared by exposing the precursor solution to ultrasonic waves for a reaction time of 3 hrs. The precipitate was collected, washed, dried and calcinated at a temperature of 500°C for 1 hour. The samples have been subjected to various characterizations. The phase and structure of the samples have been identified using X-ray diffraction. The spherical morphology of the synthesized particles have been identified by Scanning electron microscope (SEM). The absorbance spectra have been recorded in the UV-Visible region and analyzed. The FTIR spectra shows the presence of different functional group present in the synthesized nanoparticles.

Key words: Cds:Zn, Nanostructures, Spherical shaped, Zn concentration.

1. Introduction

In recent years, semiconductor nanoparticles have received broad attentions because of their interesting and novel electronic, thermo electronic and optical properties intrinsically associated with their low dimensionality and the quantum confinement effect[1].

CdS is an important semiconductor with excellent physical properties and band gap energy of 2.42eV. It has been extensively studied due to its potential application in field effect transistor, light emitting diodes, photocatalysts, biological sensor, solar cells, and photo degradation of water pollutans [3-5]. CdS nanoparticles doped with transition metals are strongly influenced by the doped transmission metals [6]. Transition metals doped with CdS nanoparticles with good structural magnetic and optical qualities have been prepared with variety of techniques such as surfactant assisted synthesis, chemical precipitation method, spray pyrolysis, ultrasonic method, etc., II-VI semiconductor nanoparticles especially Cd1-x-xZnxS ternary system has received considerable attention because of it is potential applications in solar cells and flat panel display fabrication[2]. In this work Ultrasonication approach has been adopted to synthesis CdS:Zn nanoparticles. Ultrasonic method has a several advantages as it is a

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faster process and a simple way to prepare nanomaterials. The effect of Zn concentration on the properties of CdS: Zn nanoparticles has been evaluated and reported here.

2. Experimental procedure

CdS:Zn nanoparticles have been successfully synthesized using ultrasonication method. 99% Cadmium nitrate (extra pure), 98% Zinc nitrate (extra pure), 98% Sodium Sulfide (extra pure), and Citric acid, 99% Ethanol were used as starting materials. In the typical synthesis, 0.1M cadmium nitrate and 0.1M Zinc nitrate were separately dissolved in ethanol. Both the solutions were mixed and stirred well. This solution was taken in the burette and 0.1M Na_2S solution dissolved in ethanol was added drop by drop. The final solution thus obtained was kept in an ultrasonic bath for 3 hrs. Yellowish precipitation was formed as final product. The precipitate was washed thoroughly and dried at 60°C for 3 hrs. The sample was collected and calcinated at 500°C for 1 hour. Similar procedure was adopted for preparing another set of sample except the concentration of Zinc nitrate was varied as required. Finally, the prepared CdS: Zn nanoparticles were send for further characterizations in order to study their properties.

3. Result and discussions

3.1. Structure Analysis

Figure 1 shows the XRD patterns for CdS:Zn nanoparticles.As can be seen, the diffraction peaks corresponding to (1 0 1), (2 0 0), (1 0 2),and (4 0 0) planes of cubic crystal gradually shift to larger diffraction angles as the Zn content increased. This can be attributed to the formation of CdS:Zn nanoparticles. The peak broadening in the patterns indicates that the CdS:Zn nanoparticles are very small in size. [7]

The XRD data were used to estimate the average size of constituent crystallites by Scherer's equation [8]. The average crystallite size, D, was determined as follows:

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

Where

λisthewavelength of X-rayradiation(0.15406nm), K is the constant (K=0.9), the characteristic X-ray radiation and the full-width-at-half-maximum of the (101) plane (in radians). The crystallite sizes as calculated were found to be 9 and 10 nm for sample prepared with 0.005 and 0.01 mol Zn concentrations respectively.

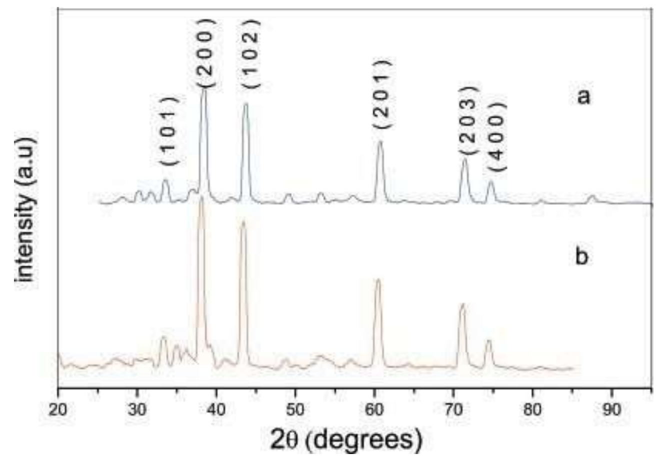

Fig.1. XRD Pattern of the CdS: Zn Nanoparticles with different Zn concentration (a) 0.005 mol (b) 0.01 mol

3.2 Morphological Analysis

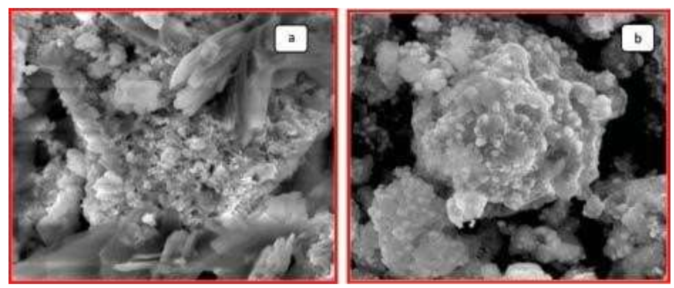

Fig.2. SEM image of the CdS:Zn Nanoparticles with different Zn concentration (a) 0.005 mole (b) 0.01 mole

SEM micrographs of synthesized CdS: Zn nanoparticles with Zn concentrations 0.005 and 0.01 mole are shown in figure 2 (a and b) respectively. The sample prepared with a lower concentration of Zn shows some flake like appearances on the surface of the sample (fig2a). However these flakes have been completely deformed into smaller spheres in the sample prepared with higher Zn concentration. The SEM image in fig 2b clearly indicates the formation of nano size particles with the average particle size around10 nm.

3.3 Vibrational Analysis

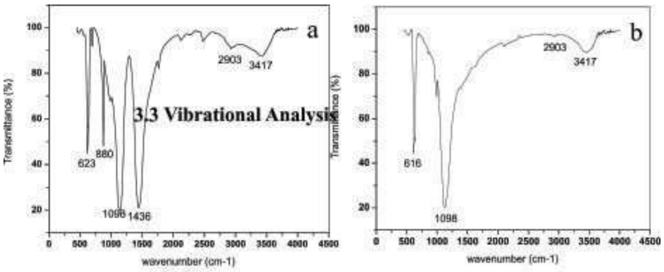

Fig.3. FTIR Analysis of the CdS:Zn Nanoparticles with different Zn concentration (a) 0.005 mol (b) 0.01 mol

FT-IR spectra of pure CdS:Zn nanoparticle are shown in Figure 3. The presence of strong absorption band in the region between 600 and 700 cm^{-1} is due to Cd–S stretching vibration. The absorption peak occurs at 880 cm^{-1} due to stretching vibration of sulfer. The weak absorption band appeared at 1098cm^{-1} due to Zn–S stretching mode[9], and may be due to some amount of Cd^{2} replaced by Zn^{2} ions [10]. The weak peaks at 2360, 2343 and 1645 cm^{-1} can be attributed to microstructure formation present in the samples.

4. Conclusion

CdS:Zn Nanoparticles were prepared by ultrasonic method. The proposed method is known as fast simple and easy way to prepare nanomaterials. The grain size as calculated from XRD using debye-scherer formula was 9 and 10 nm for 0.005 and 0.01 mole Zn concentration. The SEM results showed that the synthesized particles were spherical in shape. The presence of the CdS:Zn was identified through FTIR. As the Zn concentration is increased the properties of the prepared sample seem to get enhanced.

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