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RESEARCH ARTICLE

STRUCTURAL AND OPTICAL PROPERTIES OF CADMIUM SULFIDE NANOPARTICLES PREPARED BY PRECIPITATION METHOD

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ABSTRACT

Cadmium Sulfide nanoparticles were prepared by a simple and cost effective precipitation method. X-ray analysis revealed broad diffraction peaks indicating that the particles are of very small size. The prominent broad peaks at 2θ values of 26.48°, 43.90°, and 51.91°, which could be indexed to the (002), (110) and (112) direction of the hexagonal phase of CdS. Optical studies showed maximum absorbance in the UV region but minimum absorbance in the VIS-NIR regions make it an excellent material for screening off UV portion of electromagnetic spectrum in UV filters and sensors.

Keywords: Cadmium Sulfide, XRD, UV-Vis-IR.

1. INTRODUCTION

Semiconductor nanoparticles has been an interesting field of research for more than three decades because it gives an opportunity to understand the physical properties in low dimensions and to explore their potential applications in the field of optoelectronics [1-3]. The optical properties are particularly based on the large variations of the band gap as a function of particle size, which is a consequence of quantum confinement [4-6]. The confinement effect is observed for Cadmium Sulfide (CdS) nanoparticles when the particle sizes are equal to or less than 50 Å [4,5]. The optical properties of CdS nanoparticles have been extensively studied in recent years as this material exhibits pronounced quantum size effects [7]. A lot of work has been done on the synthesis of these nanoparticles, and a wet chemical synthesis has come up as a promising technique because of the ability to produce various sizes and large quantities of the nanoparticles [7,8]. Since very small nanoparticles have larger surface to volume ratios, many properties are directly related to the particle surface. The surface properties of the nanoparticles have been studied much less than the bulk properties, even though this information is of significant importance, and therefore many interesting aspects of nanoparticles are still not revealed. In the present work an attempt has been made to study the structural and optical properties of CdS nanoparticles prepared by chemical precipitating method.

2. EXPERIMENTAL

2.1. Synthesis of CdS nanoparticles

Aqueous solution of cadmium nitrate ($Cd(NO_3)_2.4H_2O$) was stirred for 1 hour at room temperature. Aqueous solution of sodium sulfide (Na_2S) was added drop wise to cadmium nitrate solution and was stirred for 2 hours. A precipitate with yellowish orange color was formed soon after the addition of Na_2S. The nanoparticles were initially purified by precipitating the particles with excess double distilled water and the solution obtained was centrifuged at 3000 rpm for 5 minutes. CdS nanoparticles were obtained after the precipitate was dried at 100^0C for three hours.

The structural properties were studied by X-ray diffraction (XRD) using Bruker AXS D8 Advance diffractometer with Cukα radiation (k = 1.5406 Å) operating at voltage of 40 kV and a current of 30 mA. Optical properties were studied by JASCO 670 UV–Vis–NIR spectrophotometer.

3. RESULTS AND DISCUSSION

The structural characterization of the CdS nanoparticles has been carried out by X-ray diffraction technique using CuKα radiation. Figure 1 shows the X-ray diffraction pattern of the prepared CdS nanoparticles. The X-ray diffraction peaks are found to be very broad indicating that the particles are of very small size. The x-ray diffraction pattern exhibits prominent broad peaks at 2θ values of 26.48°, 43.90°, and 51.91°, which could be indexed to the (002), (110) and (112) direction of the hexagonal phase of CdS.

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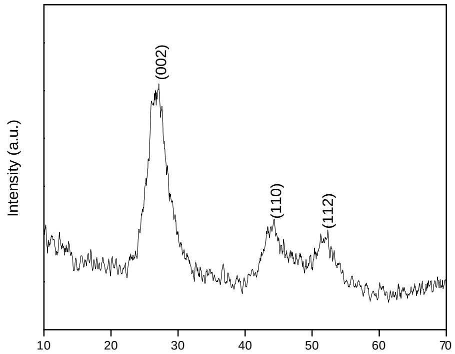

Fig.1. XRD spectra of CdS nanoparticles.

The lattice constants a and c have been determined from the interplanar spacing of the different (hkl) planes using the relation

$$(d_{hkl})^{-2} = \frac{4}{3}\frac{h^2 + hk + k^2}{a^2} + \left(\frac{l}{c}\right)^2$$

The evaluated lattice parameters of CdS are a = 4.142Å and c = 6.724Å, and are in good agreement with the standard JCPDS values (JCPDS# 02-0549). The average grain size has been determined using Scherer's equation.

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

where, D is the grain size, K is a constant taken to be 0.94, λ is the wavelength of the x-ray radiation, β is the full width at half maximum and θ is the angle of diffraction. The crystallite size has been found to be 2.8 nm.

3.1. Optical properties

The optical absorbance spectrum of the CdS nanoparticles is shown in Fig. 2. The maximum absorbance occurred within the UV region from where the absorbance decreased with the wavelength towards the NIR region.

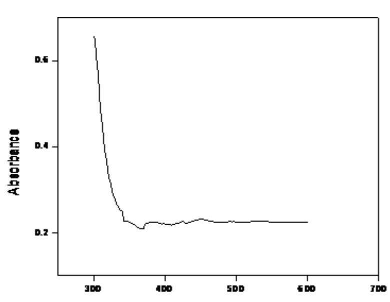

Fig. 2. Absorbance *vs* Wavelength plot

The properties of maximum absorbance in the UV region but minimum absorbance in the VIS-NIR regions make it an excellent material for screening off UV portion of electromagnetic spectrum in UV filters and sensors. The optical absorption in the shorter wave length region is mainly attributed to the electron transition from the top of the valence band to the bottom of the conduction band. The property of low absorptions (high transmittance) and low reflectance in the visible region makes the material a good candidate as transparent windows in solar cells.

4. CONCLUSION

A simple and cost effective precipitation method was used to prepare CdS nanoparticles. X-ray analysis revealed that the crystallite size of the CdS nanoparticles is found to be about 2.8 nm. Optical analysis showed maximum absorbance in the UV region indicated that the prepared CdS nanoparticles could be used as UV filters and Sensors.

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