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SYNTHESIS OF CdS NANOPARTICLES USING GLUCOSE AS A CAPPING AGENT

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In recent years the synthesis of stabilized cadmium sulfide nanoparticles has attracted particular attention owing to their optical, luminescence and photoconducting properties. In the present work, a simple method is followed to synthesize glucose capped CdS nanoparticles. The CdS nanoparticles were characterized by X-ray diffraction (XRD), UV-vis absorption spectra and photoluminescence (PL) spectroscopy. Hexagonal wurtzite structure of CdS nanoparticles was confirmed from X-ray diffraction analysis. The room temperature photoluminescence spectra of the as-synthesized CdS showed a broad and a strong peak at around 420 nm.

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1. Introduction

Size dependent optical and electronic properties of semiconductors have created the keen interest in nanometer-scale particles [1-5]. Semiconductor nanoparticles have physical and chemical properties that may differ significantly from those of the bulk material. Such deviations are attributed to the small size of the particle and the accompanying surface structure effects. By controlling the size of the particle and surface structures the semiconductor materials, the electronic, optical, magnetic, mechanical, and chemical properties can be modified to suit a wide range of device application in many fields [6]. To fulfill theses needs, chemists are emphasizing to develop new methods for synthesizing the materials in nanometer-range.

CdS is an II–VI semiconductor having direct band gap energy (Eg) of 2.4 eV at room temperature. Moreover, it has been known as one of the most promising photo-sensitive materials owing to its unique photochemical activities and strong visible-light absorption and emission [7]. Recently, semiconductor CdS nanoparticles has been widely studied and synthesized, because it has unique properties and interesting for photoreactivity and photocatalyst application. The properties of CdS nanoparticles driven mainly by two factors which are the increase in the surface to volume ratio and a drastic changes in the electronic structure of the material due to quantum mechanical effects with decreasing particles size.

2. Experimental

CdS nanoparticles were obtained by using highly pure cadmium nitrate, sodium hydroxide and glucose. Sodium sulfide was used as a source of S^{2-} ions. All the analytical grade reagents were used. The aqueous solution of cadmium nitrate (0.1M) was prepared followed by the addition of solution of sodium hydroxide solution in round bottom flask and stirred for 15 h. The dilute solution glycine was added slowly to the salt solution. In order to check the effect of stabilizer concentration, different concentrations of glucose viz. 0.001M (sample G-I), 0.01M (sample G-II) and 0.1M (sample G-III) were used. The resultant mixture was further heated at temperature

<100^{O}C for several h. The yellow reaction mixture was allowed to evaporate at room temperature to obtain yellow colored CdS nanoparticles. The dried CdS powders were characterized by X-ray diffraction (XRD) analysis. The optical properties of the CdS nanoparticles have been studied by UV-visible (UV-vis) absorption spectroscopy and photoluminescence (PL) to further assess their quality.

3. Results and discussions

Results of the X-ray diffraction studies were carried out for glycine capped CdS samples and a typical pattern for sample G-III is presented in Fig. 1. The XRD patterns revels that, the particle size is dependent on the concentration of glycine. The particle sizes (d) were calculated using Debye Scherrer equation.

$$d = 0.9\lambda/B\cos\theta \quad (1)$$

where, λ is the wavelength of the X-ray used, θ is the angle of reflection and B is the full width at half maximum.

From Fig.1, it can be seen that broad peaks that observed in the XRD patterns of CdS are belonging to hexagonal structure of CdS nanocrystals. The mean particle diameter is calculated to be 7.4 nm from the Scherrer formula**.** The CdS nanoparticles could possesses the hexagonal phases with (002) plane. Hailin Hu et al have reported the hexagonal wurtzite structure of CdS for the plane (002) [8]. The hexagonal phase of CdS has two main peaks at 28.3^{O} (101 planes) and 48.1^{O} (103 planes) whereas the cubic phase has three main peaks at 26.5^{O} (111 planes), 43.9^{O} (220 planes) and 51.9^{O} (311planes) [9]. The absence of planes referring to cubic structured CdS in XRD patterns of glucose capped CdS indicates the presence of only hexagonal CdS nanoparticles. Furthermore, the broadening of peaks suggests the effect of glucose concentration on particle size of CdS.

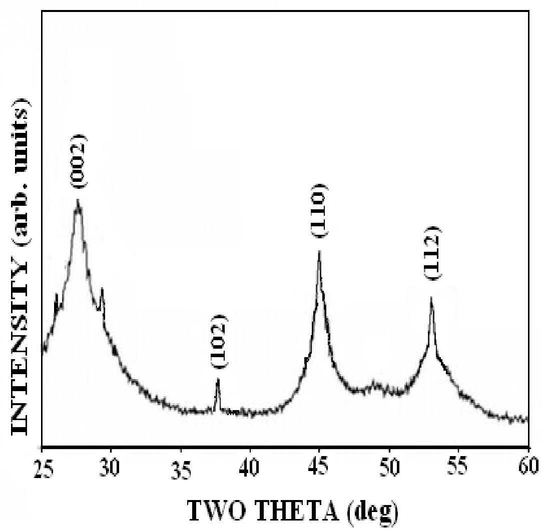

Fig. 1 XRD pattern of CdS nanoparticles capped with 0.1M glucose (sample G-III).

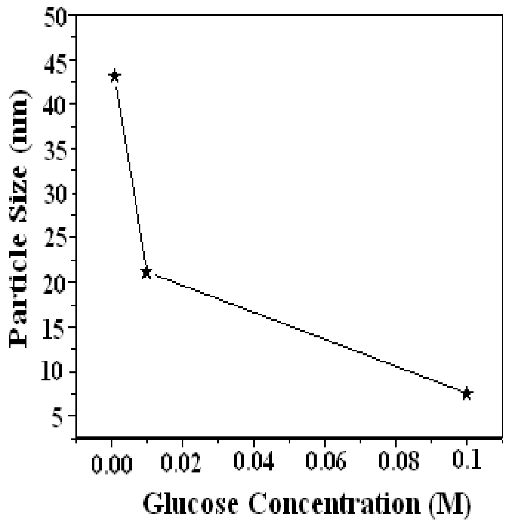

Fig. 2 Effect of glucose concentration (M) on particles size of CdS.

Fig. 2 depicts the effect of concentration of glucose on the particle size of CdS synthesized in the present investigation. One can see that, 0.1M concentration is suitable to get the particle size <7 nm. It was significant to increase the glucose concentration from 0.001M to 0.1M as the particles decreases gradually in this response. From the findings, we have concluded that, 0.001M glucose solution is unable to prevent the agglomeration of CdS particles. On the other hand, in synthesis of sample G-III, 0.1M glucose solution made it possible to get fine CdS particles by showing proper capping activity. Owing to formation of the finest particle size of sample G-III in this work, the further results are presented for this sample only.

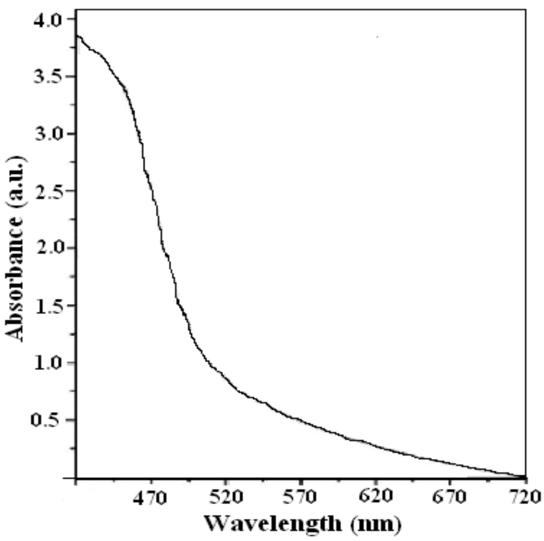

Fig. 3 UV-vis. absorption spectra of sample G-III.

UV–visible absorption spectra were recorded for as-synthesized CdS nanoparticles. Figure 3 displays UV- absorption spectra of sample G-III. The onset of the absorption of sample G-III was can be seen at 420 nm. The optical absorption coefficient has been calculated in the wavelength region of 400-650 nm.

The optical properties of glucose capped CdS nanoparticles were characterized by PL measurements at the room temperature. Figure 4 shows PL spectra of as-synthesized CdS nanoparticles. Bulk CdS absorbs visible light because of its narrow bandgap (2.4 eV) [10-12].

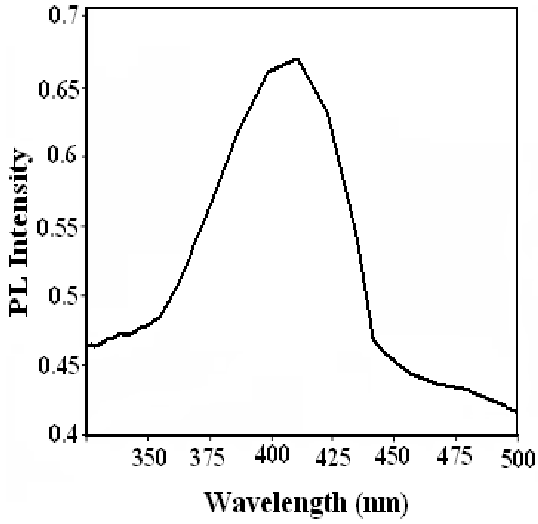

Fig. 4 Photoluminescence spectra of sample G-III.

The photoluminescence originates from the recombination of surface states [13]. Absorption of light by CdS increases by increasing its surface area. Both surface area and bandgap can be increased when the particle size reduces to nano dimensions. At nanometric sizes, quantum confinement effects can come into play and affect most notably the electronic properties [14]. Therefore, the perceptible attention has been paid to prevent the agglomeration of CdS particles in order to improve their photoluminescence properties. Photoluminescence measurements at room temperature show that the sample G-III emits a strong as well as stable bluish light and broad luminescent peak at about 420 nm. We assigned the first peak due to band gap transitions while the latter was due to sulfur vacancy in the CdS nanoparticles. S.K. Mandal et al have reported the appearance of a peak centered at 425 nm in photoluminescence spectra of ZnS [15].

4. Conclusions

CdS nanoparticles were synthesized by a simple chemical route using glucose as a capping agent. Particle size in the CdS colloids decreases with increasing in glucose concentration. The capping of CdS nanoparticles by 0.1M glucose solution successfully prevents the aggregation of CdS particles. The XRD results showed that the size of CdS nanoparticles are <7 nm with 0.1M glucose solution. This factor improves the photoluminescence properties of CdS. Finally, our development glucose capped synthesis of CdS nanoparticles is expected to contribute to solar cell research or material for light-emitting diodes and optical devices.

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