

## **Structural and Optical Properties of Chemically Grown CdSe Nanoparticles**

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### **ABSTRACT**

In the present work a simple chemical reduction route has been followed to grow CdSe (size controlled) nanoparticles at room temperature. The grown sample has been ultra-sonicated in ethanol. The dispersed sample has been characterized structurally, optically. The result supports the formation of nanoparticles and hence an increase in band gap compared to bulk CdSe (bulk band gap is 1.74 eV).

**Keywords:** CdSe nanoparticles, Microstructural properties, Optical properties, Photoluminescence

### **1. Introduction**

Semiconductor compounds of the II–VI group have drawn considerable interest due to their potential applications in photovoltaic devices, photo-resistors, heterojunction diodes, electroluminescent layers and surface acoustic wave devices. Chalcogenides, especially of cadmium, lead and zinc, have proved their potential as efficient absorbers of electromagnetic radiation [1–3]. Cadmium chalcogenides form a technically important class of materials owing to their widespread utility in a variety of electronic and optoelectronic devices [4]. CdSe thin films are well known for their extensive applications as an optoelectronic material in solar cells and photodetectors. They are also used in the fabrication of optical filters, multilayer LEDs, photodiodes, phototransistors, etc. Heterojunction solar cells with a wide bandgap window and a narrow bandgap absorber are currently becoming the focus of intensive research in order to develop efficient, stable and low-cost cells. Cadmium selenide, with a band gap of 2.03 eV, is an ideal material for use as the window layer of heterojunction solar cells. There are various methods[4-8] to prepare CdSe nanoparticles. Some of the above mentioned methods have some drawbacks. Used precursors are unstable causing environmental hazards and require very high temperature. These methods are not cost effective also. Hence a simple chemical reduction route has been preferred.

## 2. Experimental Section

A stoichiometric amount of anhydrous  $\text{CdCl}_2$ , selenium powder and sodium borohydride has been taken. Ethylenediamine has been used as a capping agent. Sodium borohydride has been taken to initiate the reaction at room temperature. The stirring has been continued for 3 hours at a particular speed. For TEM and TED measurements, the as-prepared CdSe nanoparticles have been dispersed in ethanol by ultrasonification. A small drop of dispersed CdSe nanoparticle has been taken on a thin carbon film supported on the copper grid and kept for some time for drying. TEM, TED and EDX of the as-prepared sample has been taken using JEOL-JEM-200 transmission electron microscope operating at 200 kV. Optical absorption measurements of the dispersed samples have been studied in the range of 500nm-800nm using Shimadzu Pharmaspec 1700 UV-VIS spectrometer. Photoluminescence spectra of the same sample have been obtained using Hitachi F-7000 FL Spectrophotometer.

## 3. Structural Properties

TEM image of the bright field of CdSe nanoparticles and its selected area diffraction pattern are shown in figure 1(a) and 1(b) respectively. Particle size is determined to be approximately 5–8 nm. A clear hexagonal phase of the as-prepared CdSe nanoparticles is revealed in the TED pattern figure 1(b). The interplaner spacing ( $d$ ) is determined from the SAD pattern. The determined  $d$  values are 3.828, 3.141, 2.213 Å for first, Second and third rings respectively. The calculated  $d$  values match well with JCPDS file values of 3.720, 3.290, 2.151 Å which corresponds to (1 0 0), (1 0 1), (1 1 0) planes respectively.

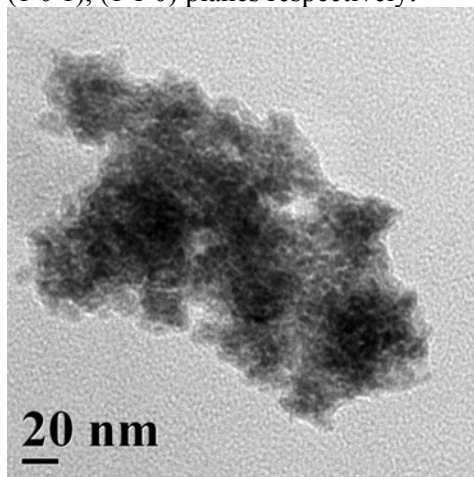


Fig.1a

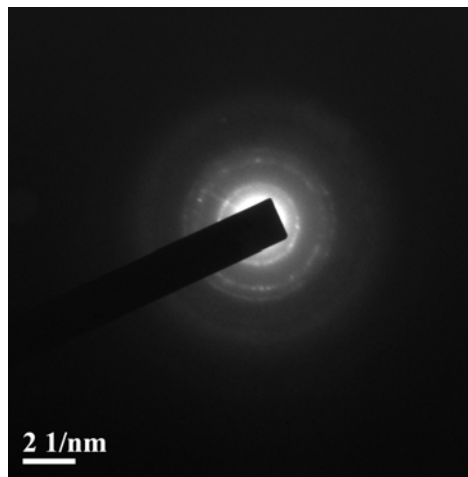


Fig.1b

Fig. 1a The TEM image of as prepared CdSe nanoparticles.

Fig. 1b The SAD pattern of as prepared CdSe nanoparticles.

#### 4. Optical Properties

Figure 2 displays the variation of optical absorbance with wavelength of the as-prepared nanoparticles. Optical absorption coefficient has been calculated in the wavelength region of 500 – 800 nm. The band gap of the as- prepared nanoparticles is determined from the relation  $(\alpha h\nu) = C (h\nu - \Delta E_g)^{1/2}$  where C is a constant,  $\Delta E_g = 2.02$  eV and is shown in figure 3, whereas the bulk band gap is 1.74eV. It confirms that the absorption peak is shifted from their bulk edge 704nm. This is due to the quantum confinement effect. Hambrock et al obtained CdSe band gap of 2.01 eV (617 nm). The photoluminescence spectra of the as-prepared CdSe nanoparticles are displayed in the figure (4). A sharp peak at 615nm is obtained . This is due to band edge luminescence. The band edge is close to the value determined by optical absorption.

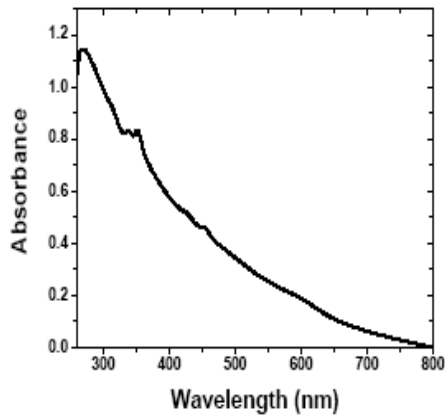


Fig- 2

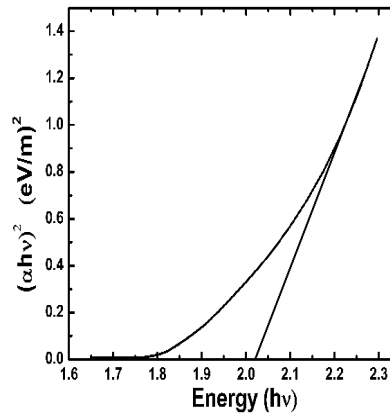


Fig-3

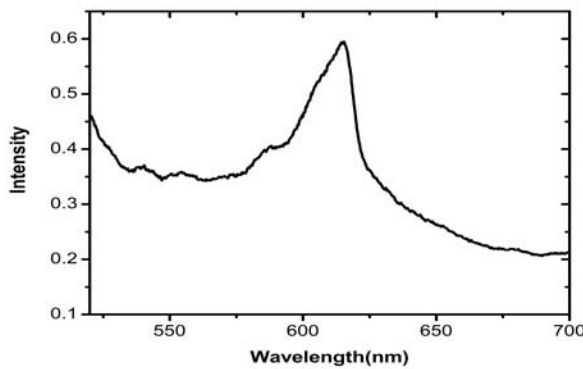


Fig-4

Fig.2 The optical absorption spectra of as prepared CdSe nanoparticles

Fig.3 The band gap determination of the as-prepared CdSe nanoparticles.

Fig.4 Photoluminescence spectra of the as- prepared CdSe-nanoparticles.

### 5. Conclusions

The CdSe nanoparticles are synthesized by simple chemical reduction route at room temperature. The TEM image shows that the sizes of the nanoparticles are in the range of 5-8nm. As a result the band gap of the material is increased which is supported by optical absorption experiment.

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