

# Characteristics of CdSe Nanocrystalline Thin Films at Two Immiscible Liquids

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## Abstract

In this paper, we report a simple method for the assembly of CdSe nanocrystals into thin films at water-hexane interface. The size and morphology of the CdSe nanocrystals were found to be dependent the reaction temperatures. The decrease in band gap and the increase in particles size with rising reaction temperatures are found to be gradual. The growth of CdSe thin films were characterized with scanning electron microscopy, transmission electron microscopy as well as UV-vis spectroscopy.

**Key words:** Nanocrystals; Cadmium selenide; Thin film; Two immiscible liquids.

## 1. Introduction

Inorganic nanocrystals have attracted a great deal of research interest because of their use in technological applications in field effect [1-8] solar cells, optoelectronic devices, high efficiency thin film transistors [9-14]. A various of methods of it's preparation have been grown. They include chemical vapour deposition, spray pyrolysis, and chemical bath deposition [15-19]. The interface of two immiscible liquids has not investigated sufficiently, and lately, there has been a lot of effort to understand the structure and properties of the liquid-liquid interface. This possesses properties different from the bulk phases due to Surface tension, density, and viscosity effects as well as interfacial emulsification [20]. The potential use of the organic –aqueous interface to assemble nanocrystals has been studied [20]. Because of the quality of the medium, assembly by the use of two immiscible liquids is less prone to defects than assembly utilizing other techniques.

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Cadmium selenide (CdSe) is a semiconductor material important for the advancement of a number of modern technologies. Recently, much effort has been devoted to the electrical and optical properties of CdSe thin film in order to improve device's performance such as solar cells and related optoelectronic devices, high efficiency thin film transistors [21-26].

Another area of interest is CdSe nanoparticles. Researchers are concentrating on improving controlled synthesis of CdSe nanoparticles. Polycrystalline thin films of CdSe have been created at the liquid/liquid interface via reacting cadmium cupferronate in organic phase with dimethyl selenourea in the aqueous phase [27]. Bawendi and co-workers [28] have synthesised CdSe nanocrystals via reacting of dimethyl cadmium and trioctyl phosphine selenide.

Here, we have successfully formed CdSe nanocrystals thin film at the interface of two immiscible liquids and describe how various reaction temperatures affect the films formed. A metal precursor dissolved in solvent such as hexane is held in contact with sodium seleno sulfate. The reaction yields at the interface of liquids and results in deposits suspended in the interface region.

## 2. Experimental section

### 2.1 Synthesis of sodium selenosulfate

Sodium selenosulfate was prepared utilizing method reported previously [29-30]. A 50 ml of water containing 1 g Se powder and 10 g sodium sulphite ( $\text{Na}_2\text{SO}_3$ ) was heated under reflux in round bottomed flask at  $70^\circ\text{C}$  for 24 h to get reddish solution. The solution was cooled at room temperature and insoluble particles was filtered to get a pure solution of sodium selenosulphate as shown in the following equation

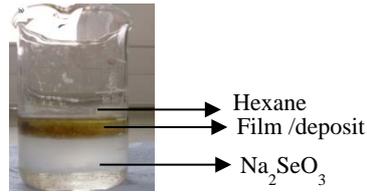


### 2.2 Synthesis and assembly of CdSe thin films

Thin film of CdSe nanocrystal was prepared by layering 30 ml of hexane containing 0.05 g of cadmiumdiethyl dithiocarbamate over 30 ml of freshly prepared solution of  $\text{Na}_2\text{SeSO}_3$  whose pH was adjusted to less than 10 ~9 using aqueous solution of KOH. The beaker containing the liquids was moved into an oven held at  $40^\circ\text{C}$  and left for 10 h. A brown thin film was formed at the interface of two liquids as shown in figure 1. The organic layer at the top was decanted and lifting the film onto glass substrate. The reactions happened are [30] :



The surface morphology and optical properties of thin films has effected by rising the reaction temperatures from  $40^\circ\text{C}$  to  $60^\circ\text{C}$  .it was then study the effect of temperature on the properties.



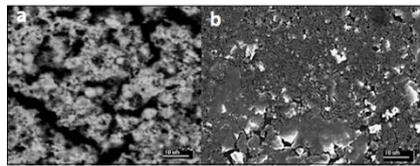
**Figure 1:** Nanocrystalline films of CdSe formed at the water –hexane interface.

### 3. Characterization of CdSe

CdSe films at the water-hexane interface were transferred to glass substrates and Transmission electron microscopy (TEM) grids to analysis by: TEM which was carried out with a Philips CM200 electron microscope operating at 200 keV. Scanning electron microscopy (SEM) was performed using Philips Excel SEM equipped with a 30 kV F.E.G. Extinction spectra were recorded using Cary 5000 UV-vis-NIR spectrophotometer.

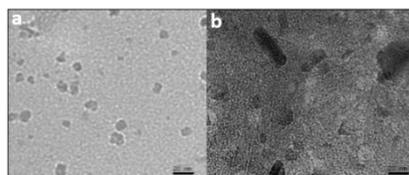
### 4. Results and discussion

Figure 2 SEM images of the synthesized CdSe thin films formed at the interface, it displays the morphology of CdSe nanocrystals. It reveals changing surface morphology as the temperature rising from 40°C to 60°C. At 40°C is apparent spherical grains with granules and critical size ranging from several nanometers to a micrometer. While films obtained at 60°C were fairly to be consisted of globular clusters with microscopic dimensions



**Figure 2:** SEM images of CdSe thin films deposited at the water – hexane (a) at 40°C and (b) at 60°C

TEM images of CdSe, synthesized at two different temperatures are shown in figure 3. The dimension of these grains is controlled by the temperature, with the rise of reaction temperatures from 40°C to 60°C the average diameter of CdSe nanocrystals increases from 10 nm to 18.74 nm.



**Figure 3:** TEM images of CdSe thin films nanocrystals formed at interface (a) at 40°C and (b) at 60°C

Previous reports have been successful in depositing cubic CdSe films of CdSe nanocrystals with diameters ranging from 8-20 nm [31].

The absorption spectra exhibited by rising reaction temperatures from 40°C to 60°C the band edge blue shifts from 1.80 eV to 1.71 eV. The adsorption edge was calculated using the Tauc relation [32].

$$(\alpha h\nu) = \text{constant} (h\nu - E_g)^n$$

$E_g$  is the band gap ( $n$ ) is a constant equal to 0.5 for direct band gap semiconductors [30]. The energy gap calculated by a graph is plotted between the  $(\alpha h\nu)^2$  against  $h\nu$  to get a straight line figure 4. The extrapolation of the line to gives the value of the absorption edge. The edge shifted from 1.80 eV at 40°C to 1.71 eV at 60°C According to previous method [33-35], the change in band edge due to an increase in diameter from 14 to 19 nm. This is higher than estimates from TEM images.

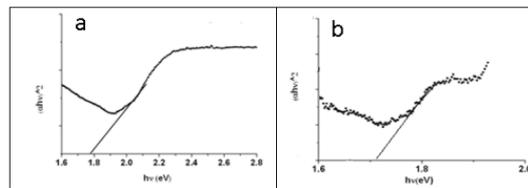


Figure 4: Absorption spectra of CdSe thin film formed at water-hexane interface , the plots used to determine the optical band gaps of CdSe thin film obtained (a) at 40°C and (b) at 60°C.

## 5. Conclusion

CdSe thin films have been formed at the interface of water and hexane, utilizing cadmium diethyldithiocarbamate as metal source and  $\text{Na}_2\text{SeSO}_3$  as selenium source. The increasing the temperature from 40°C to 60°C almost increases the nanocrystals average diameter from 10 nm to 18.74 nm. SEM images showed changing the surface morphology and UV-visible spectroscopy found that the band gap changes by decreasing from 1.80 eV to 1.71 eV.

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