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PREPARATION OF CdSe QUANTUM DOTS BY SIMPLE KINETIC GROWTH METHOD

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Nanostructured materials can be defined as those materials whose structural elements clusters, crystallites or molecules - have dimensions in the 1-100 nm range. High quality quantum dots have been prepared with advances in the modern colloid chemistry. In the present study we have focused on preparation of CdSe quantum dots (QDs).CdSe prepared via colloidal synthesis in aqueous medium. CdSe QDs optical properties and size were characterized by ultraviolet-visible (UV-vis) absorption spectra, Photoluminescence spectra and DLS measurement. The result showed that the absorption spectra clearly indicate the absorption peak shift from 500 nm to 600 nm on increasing. The particle size average diameter of the CdSe quantum dot is reported as 12.26nm.

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1. Introduction

The chalcogenide semiconductor nanocrystals have fascinated much consideration due to their physical properties, electronic properties arising from the quantum confinement of electrons, size-dependent and promising applications in nanotechnology [1]. Chalcogenide based Quantum dots (ChQDs) are exceptional class nanomaterials, with crystals of only a few hundred to thousands of atoms owing to their small size, around 2-10nm. Among the ChQDs, Cadmium sulfide (CdS) and cadmium selenide (CdSe) are typical II-IV group semiconductors. CdSe QDs are chosen as model structures to study quantum size effects occurred at the nanoscale. Because they have a direct energy band gap (2.42 eV of CdS, 1.70 eV of CdSe) and high electron mobility (200 cm-2/V·s and 800 cm-2/V·s) [2], these materials are used widely in many applications, such as luminescence, biosensor, solar cells and as photo-catalysts [3]. Owing to their slender band gaps and relatively negative potentials valence band, they exhibit excellent absorption properties in the visible light region, which affords them good photocatalytic activity under visible light radiation [4-6].

According to the literature, CdS and CdSe are used as sensitizers when combined with other semi-conductors in photocatalytic. Interesting size-tailored photoluminescence and strong resistance against photochemical reaction in solution, quantum dots have been widely potential applications electronics such as luminescent devices, Quantum dot laser, super capacitor, photo detectors, chemical sensors, field effect transistors, solar energy converters and photo catalytic devices [7]. For example, when CdSe is combined with TiO_2, ZnS, ZnO, CdO, CdS and these cascade structures exhibit enhancement in their optical absorption property and photocatalytic performance [8].

2. Experimental details

Cadmium oxide (99.998%) and Sulphur was acquired from chennai chemicals, Trioctylphosphine (90%), Trioctylphosphineoxide (90%), Octadecene and selenium powder (Se, 99.99%) and oleic acid were bought from Aldrich Chem. Co.

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CdSe nanocrystals are produced from CdO and elemental Se by means of a kinetic growth technique [25-28] where particle size be contingent on response time. A standard solution of Se precursor prepared ahead of time by coalescing 60 mg of Se and 10 ml of 1-octadecene (tech., 90%) in a 100-mL round-bottom flask fixed over a hot plate stirrer. A syringe is used to measure 0.8 mL of trioctylphosphine from a sealed bottle to the same 100 ml flask. A magnetic stir piece is added into the solution and stirred for 60 min. It is heated at 60℃ to rapidity dissolution of Se. The standard solution is put in safekeeping at room temperature in a sealed container and has enough Se precursors for the preparations. The Cd precursor is prepared by adding 65 mg of CdO to a 250-mL round-bottom bottle clamped in a heating mantle. To the same bottle 3 ml of oleic acid and 50 ml of octadecene are added. A thermometer capable of gaging 200℃ is inserted, the temperature to which the flask is then heated. When the heat touches 200℃, 5 mL of the room-temperature selenium solution is transferred to the 200℃ cadmium solution. The physical characteristics of the products depend on reaction time, one should begin timing when the selenium solution is added. An 8-inch pipe is used to remove and quench approximately 2 ml samples at frequent time intervals (2 mins, 4 mins and 6 mins) as quickly as possible in the beginning and when noticeable colour change is detected at later times. The set of CdSe QDs are shown in Fig. 1. The samples were pipetted out within six minutes and also we can see three different colours which indicate that different sizes of CdSe QD'S.

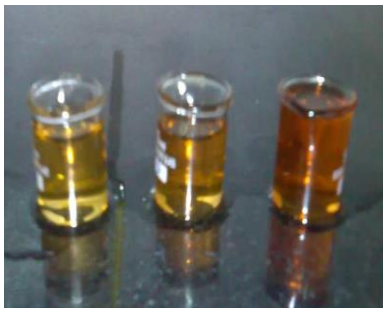


Fig. 1. Colloidal suspension of CdSe QD'S of increasing size at frequent time intervals (2mins, 4mins and 6mins).

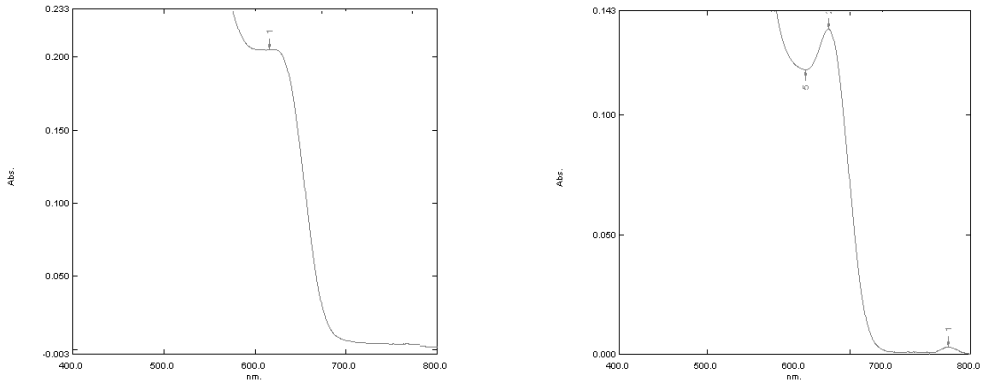
3. Result and discussion

A most important challenge in nano-crystal synthesis is the assembly of mono-disperse elements. The element shows a relatively fine size dispersal, resultant in thin absorbance and emission peaks are called as mono-disperse. The development of CdSe QDs could be recognized by the color transformation in the UV-Vis spectra. DLS measurement also gives the size dispersal and the average size of the prepared sample. The results found from the different measurements are deliberated below.

3.1. Optical Absorption

3.1.1. UV Spectrum for CdSe QD'S

The optical absorption wavelength was measured by using UV spectrometer and spectrum was taken for CdSe samples. The absorbance spectra of samples pipetted at different reaction times of 4mins and 6mins after injection of Se precursor is given in Fig. 2. The absorption spectrum shows striking excitonic features around 500 nm to 600 nm in the visible range. The absorption spectra clearly indicates that the absorption peak shift from 500 nm to 600 nm on increasing the particle size. It should be noted that such pronounced absorption spectrum predicts good crystallinity in the sample and also confirms that the material is a semiconductor.



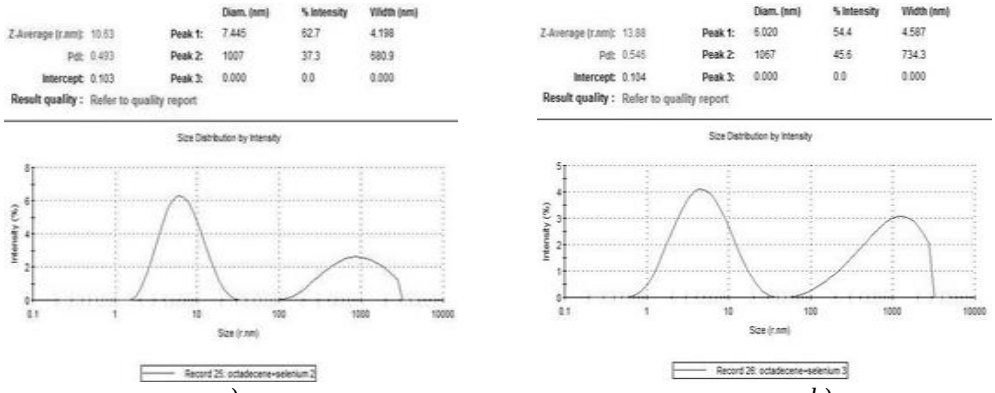
a) *b)*

Fig. 2. UV Spectrum for CdSe QD'S a) Light brownish (4 mins) Size-547nm & absorption-0.210, b) brownish (6 mins) Size -563.1nm & absorption -0.133.

3.2. DLS (Dynamic Light Scattering) measurement

3.2.1. Particle size for CdSe QD'S

Dynamic Laser Light Scattering experiments were carried out for measuring the Size of the prepared CdSe QD'S. The average Size Distribution Report of the CdSe QD'S samples dispersed in an organic solvent octadecene and pipetted at different reaction times of 2 mins and 6 mins after injection of Se precursor is shown in the below Fig. 3.2.1. The average diameters of the CdSe QD'S are reported as 10.63nm for light brownish color (4mins) and 13.88nm for brownish color sample (6mins).



a) *b)*

Fig. 3. Average diameter of the CdSe quantum dots,
a) 10.63nm for light brownish color (4mins) and
b) 13.88nm for brownish color sample (6mins).

3.3. Photoluminescence

3.3.1. PL Spectrum for CdSe QD'S

The photoluminescence spectra emission maximum of CdSe is at 600nm, consistent with the red shifts visible in the absorption spectra. More importantly, the intensity of the emission maximum, which is normalized to the absorption spectrum, is considerably increased in the core/shell structure as compared to the parent materials (CdSe).

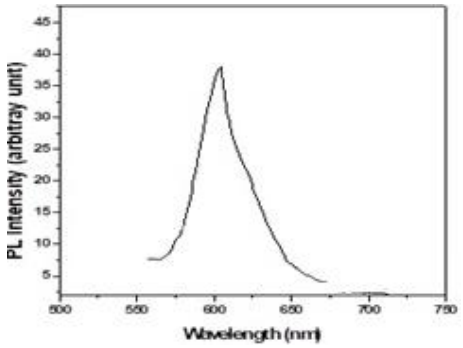


Fig. 4.Photoluminescence spectrum (λex= 400nm) of CdSe.

4. Conclusions

CdSe QD'S has been prepared from Cadmium oxide, Sulphur, Octadecene, stearic acid, Trioctylphosphine, Trioctylphosphineoxide, and selenium powder precursors. CdSe QD'S optical properties are discussed elaborately. The absorption and emission spectra of CdSe QD'S structures has shown in figures. Particle Size Analyzer value shows prepared QD'S are 12nm to 14nm in the range.

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