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Photo-luminescence of CdSe quantum dots suspended in liquid paraffin

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We report chemical route for synthesis of CdSe quantum dots (QDs) and its characterizations by UV/Vis Spectroscopy (UV/Vis), X-Ray Diffraction study (XRD) and High Resolution Transmission Electron Microscopy (HRTEM). Further, Electroluminescence (EL) spectroscopy has been carried out to investigate the light emitting phenomena of the samples when biased with electrical energy (Voltage). The average quantum dot size ranges from 7 nm to 8.2 nm. Electroluminescence reveals green luminescence and indicates the application of CdSe quantum dots as light emitting devices (LEDs).

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1. Introduction

Semiconductor nanoparticles and their different potential applications have attracted the recent researchers at present [1-17]. Among these II-VI semiconductors (CdS, CdSe, CdTe, ZnS, ZnSe and ZnTe etc) have generated intensed interest over a few decades in the fields of physics, chemistry, and engineering [1] and researches in this area have been gaining momentum because of their probable wide-spread applications, especially in Electronics as Nano Switches or nano light emitting device (nano LEDs) [3]. In the present investigation, it is an attempt to highlight the synthesis, characterization and luminescence study of CdSe quantum dots [1-9] which are basically a three dimensionally confined nanoparticles. The samples have been examined by UV/VIS absorption spectroscopy to reveal the blue shift. X-ray diffraction study (XRD) and Transmission electron microscopy (TEM) explores the size of the prepared sample while Electroluminescence (EL) study reveals the energy state in CdSe causing its luminescence. Similar works on other semiconductor nanoparticles eg. CdS, ZnS etc. has been reported [10-13] by several workers earlier but no such extensive investigation on electroluminescence has been carried out on CdSe. Hence, the present work demands its novelty.

2. Experimental

For synthesis [14-17] of CdSe quantum dots, we prefer chemical method because of its many advantages over other methods. The main advantages are the stability and slow agglomeration rate which make the study more reliable. For synthesis of CdSe quantum dots, 78 mg of Selenium powder is mixed with 50 ml of liquid Paraffin in a beaker by continuous stirring using magnetic stirrer at 90 °C for nearly 2 hours until a bright yellow colour comes. Next, 2.56 g of Cadmium Oxide, 9.6 ml of Oleic acid and 40 ml of liquid Paraffin are mixed in another beaker by continuous stirring by magnetic stirrer at 90 °C for nearly 1 hour until a dark red colour comes. Finally, 5 ml of Cadmium precursor is quickly added to the Selenium precursor and the content is stirred continuously using magnetic stirrer for nearly 45 minutes at 90 °C until it turns red. The specimen is cooled to room temperature.

3. Results and discussions

The prepared sample of CdSe has been characterized by UV/Vis Spectroscopy (UV/Vis Spectro-photometer, Shimadzu), XRD (Bruker) and TEM (JEOL, 100CXII, 100 kV). For UV/VIS study, specimen is dispersed in ethanol and exposed to Ultra Violet and Visible region of optical signal. The absorbance v/s wavelength curve (Fig. 1) reveals a nonlinear phenomenon and a decaying absorbance with wavelength. The absorbance peak is blue shifted with respect to that of bulk [2]. By using the formula from 'Hyperbolic Band Model' [11] the average particle size is estimated to be 8 nm.

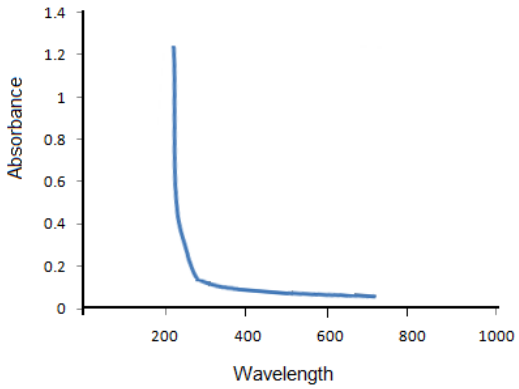

Fig. 1. UV/Vis Absorbance v/s Wavelength curve for CdSe quantum dots.

X-Ray diffraction study provides the diffractogram as shown in Fig. 2. From this graph, calculating FWHM (ω), the corresponding scattering angle (θ) and by using Debye-Scherrer formula, $D=0.9\lambda/\omega\cos\theta$, λ being the wavelength of X-Rays used in measurements (0.1541 nm), the average particle size has been estimated and found to be around 7.9 nm. From transmission electron microscopy (JEOL, 100CXII) from the image as shown in Fig. 3, the average particle size has been assessed as 6 nm.

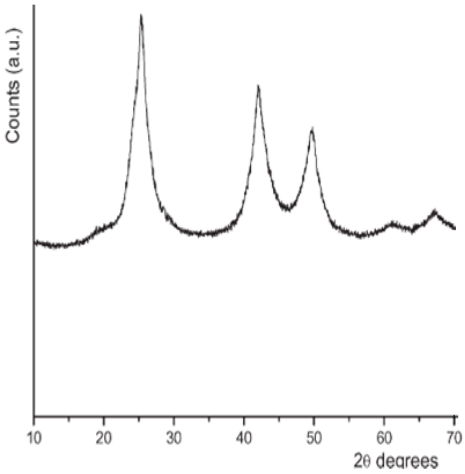

Fig. 2. X-Ray Diffractgram of the prepared CdSe quantum dots.

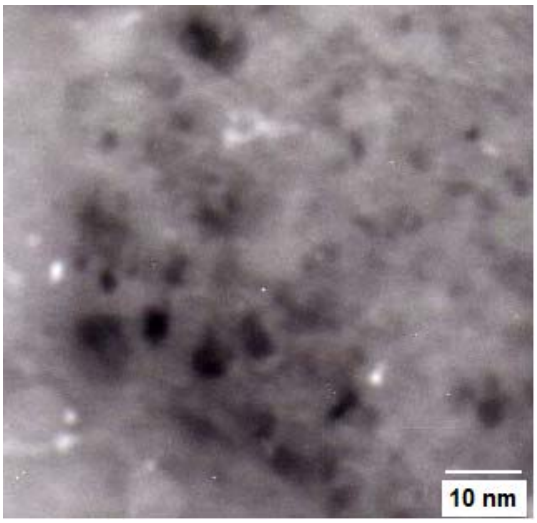

Fig. 3. TEM image of CdSe quantum dots suspended in liquid paraffin.

Electroluminescence spectroscopy (S2500, FL Spectro-photometer) is a very significant tool to investigate the internal energy state of any specimen. In the present work, the Electroluminescence (EL) study of our prepared CdSe quantum dot shows that CdSe quantum dots possess the luminescence output peak at around 540 nm as shown in Fig. 4. From the spectrum, it is clear that the luminescence intensity is considerably higher in CdSe quantum dot in compare to other quantum dots eg. ZnS:Cu as reported elsewhere [1]. Like Photoluminescence, the reason behind the Electroluminescence is also the existence surface-trapped electrons and holes created due to quantum confinement [8,14]. Thus this study reveals the possibility of CdSe quantum dot to be used as light emitting device in around green reason. The advantage of CdSe quantum dot is that the luminescence intensity is much higher than in Copper doped ZnS (ZnS:Cu) quantum dots [1,14].

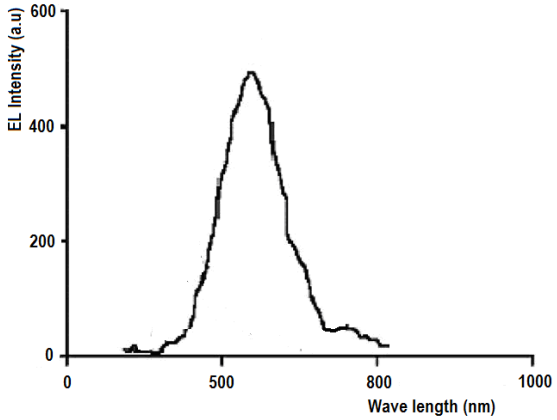

Fig. 4. EL Intensity v/s Wavelength for the prepared sample.

Fig. 5 shows the variation of EL intensity with applied ac voltage.

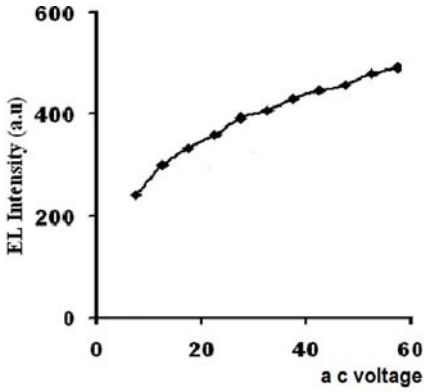

Fig. 5. Variation of EL intensity with applied ac voltages.

4. Conclusion

CdSe quantum dots has been synthesized through chemical route by using Selenium powder, Cadmium Oxide, Liquid Paraffin and Oleic Acid. Liquid paraffin acts solvent and Oleic acid acts as reaction media. The prepared CdSe quantum dots are of very narrow and uniform size within 8 nm. Electroluminescence study reveals the possible application of CdSe quantum dot as

nano light emitting device (nano LED) of very high output intensity.

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