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Characterization of Dye Sensitized CdSe Quantum Dots

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Abstract

The generation of dye sensitized solar cell (DSSC) and quantum dot-sensitized solar cells (QDSSCs) is considered as the third generation of the solar cell. Cadmium selenide (CdSe) is commonly used as n-type semiconducting layer for heterojunction thin film solar cells. In the present work, synthesis of nanoparticles of CdSe has been done using chemical precipitation technique. And extract dye from pomegranate fruit as the natural dyes. Co-sensitization by using two or more sensitizers with complementary absorption spectra to expand the spectral response range is an effective approach to enhance device performance of quantum dot sensitized solar cells (QDSSCs). To improve the light-harvesting in the visible/near-infrared (NIR) region, CdSe quantum dots (QDs) was combined with pomegranate dye for co-sensitized solar cells. . The prepared CdSe QDs were characterized by UV–Vis absorption, and PL spectra. The CdSe quantum dots were prepared successfully of size 2.9 nm synthesized used LEEH as a capping agent. The size of nanoparticles in pomegranate dye found to be 8.99nm. The proposed solution have been characterized by, UV-Visible spectra and photoluminescence studies. The size of nanoparticles is estimated from Yu model. When CdSe quantum dots are combined with dye, CdSe shows absorption from 387nm to 530nm.

Keyword- Dye Sensitized Solar Cells, PL Spectra, Quantum Dots, Quantum Confinement, UV Absorption

I. INTRODUCTION

The extremely small semiconductor structures, QDs are usually 2-10nm in diameter. It is the quantum confinement that gives rise to the size dependent properties of semiconductor nanocrystals. Electronic properties such as band gap widening, change of electrochemical potential of band edge and enhancement of photo catalytic activities with decreasing crystallite size are observed with the study of quantum confinement [1-3]. As light absorber, QDs have several advantages like tuneable energy gaps, ability of multiple exciton generation, low fabrication cost and high absorption [4]. The band gap can be controlled over a wide range by controlling the size and shape of nanoparticles and hence make it possible to prepare QDs that can absorb and emit light over the entire frequency range of the solar spectrum in the area of QDs [5].CdSe has received major attraction because of its high luminescence and good quantum yield and are usually used as n-type semiconducting layer for heterojunction thin film solar cells. In the present work, nanoparticles of CdSe is synthesized using chemical precipitation technique and dye extracted from pomegranate which can improve the light- harvesting capability[6] in the visible/near-infrared(NIR) region.UV-VIS absorption, and PL spectra are being used in characterizing the prepared quantum dot CdSe.

II. EXPERIMENTAL

The chemical procedure makes use of Cadmium Sulphate(CdSO4),selenium(Se),sodium Borohydride(NaBH4),and LEEH(L-cysteine ethyl ester hydrochloride).Solution of 1M $NaBH_4$,0.5mM Se and 0.5Mm $CdSO_4$,2 M LEEH was prepared separately.$NaBH_4$ and Se solution were taken in 1:1 ratio and the solution was placed in magnetic stirrer and stirred at 60^0C for 1 hour. The 0.5 Mm $CdSO_4$ solutions was taken separately with 20ml of DI water and 2 M LEEH was taken with 20 ml of DI separately. The above two solutions are mixed and stirred for 30 minutes at 45^0C Temperature. The solution prepared are mixed and stirred together at constant temperature of 70^0C for 1 hour. The solution was kept for 24 hours. U-V spectrum is taken after every 24 hours and spectrum was observed for 15 days. Dye is squeezed out from pomegranate fruit. The CdSe solution is combined with dye in the ratio of 1:1, 1:2 and1:3.

III. RESULT AND DISCUSSION

A. U-V Visible Spectroscopic Analysis

The optical absorption spectrum of CdSe nanoparticles was recorded at 387 nm done in UV-Vis spectrometer (Shimadzu UV-Vis 1800) and is shown in the Fig.1.and pomegranate dye has shown the peak at 535nm shown in Fig.2. After that CdSe is combined with dye in the ratio of 1:1, 1:2, 1:3 and the absorption spectrum was recorded between 387 to 530 nm. (Fig.3.)

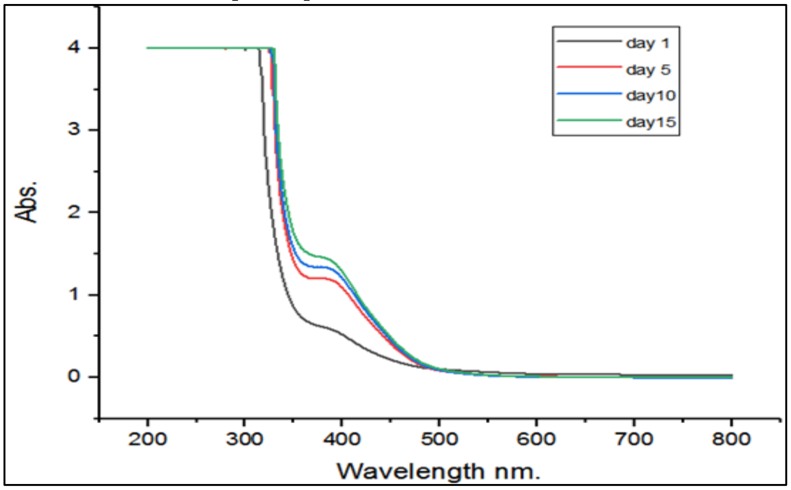

Fig. 1: U-V visible spectra of CdSe nanoparticles

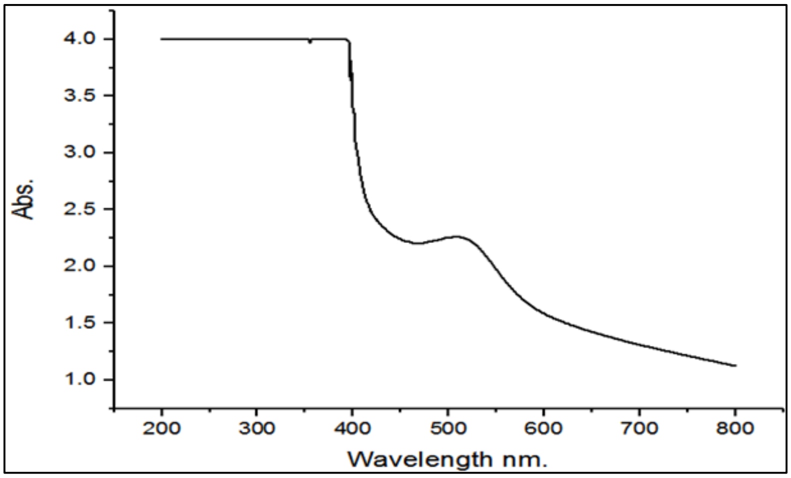

Fig. 2: UV Spectrum of pomegranate dye

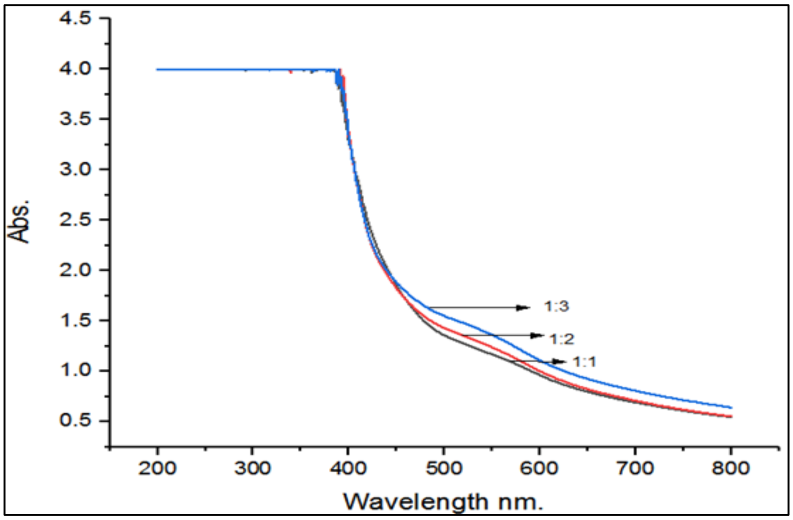

Fig. 3: U-V visible spectra of combined CdSe and dye in the ratio of 1:1, 1:2, 1:3

It is observed that band gap energy of CdSe is 3.20 eV. Optical absorption spectrum shows an gradual increase in peak with time. Pomegranate shows band gap energy of 2.3 eV. When CdSe is combined with dye in the ratio of 1:1, 1:2, 1:3, CdSe quantum dot has shown absorption energy between 2.34eV to 3.20eV which is an important parameter for extending the applications of CdSe towards solar cells. CdSe quantum dot can absorbs a range of spectrum from 387nm to 530nm (Fig.3). The largest QDs with the lowest band gap energy give the highest quantum sensitized solar cells [2].

The particle size is calculated by Yu model [3] using the relation

$$D=\left(-6.6521\times10^{-8}\right)\lambda^{3}+\left(1.9557\times10^{-4}\right)\lambda^{2}-\left(9.2352\times10^{-2}\right)\lambda+13.29$$

Where D (nm) is the size of a given nanocrystals sample and λ(nm) is wavelength of the first excitonic absorption peak of the corresponding sample. The size is estimated as 2.98 nm for CdSe nanoparticles and for pomegranate dye particles it is found to be 8.98 nm.

B. PHOTOLUMINISCENCE SPECTRAL STUDIES

Luminescence takes place from the surface of the QDs and it arises when a photon excites an electron and the electron jumps from valence energy level to a higher energy level leaving behind a hole in the valence band. This highly energetic electron releases some of its kinetic energy and settles at the lowest vacant energy level. Finally, the electron recombines with a hole, and radiates light with energy equal to the difference between the energy levels in the conduction and valence band [2]. Here Photonic emission at 490nm is the band edge emission due to recombination of the exciton in the mostly delocalized states in nanoparticles and it determines crystalline nature of nanoparticles [5-6]. The Pl (photoluminescence) spectra have been done on CdSe nanoparticles to examine the photo absorption effect which is seen in direct band gap material.

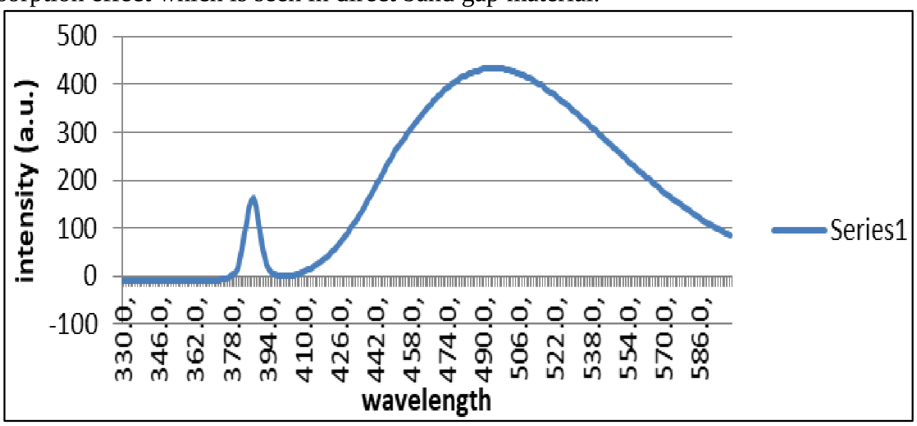

Fig. 4: photoluminiscence spectra of CdSe quantum dots

IV. CONCLUSION

The CdSe quantum dots were prepared successfully of size 2.9 nm synthesized used LEEH as a capping agent. The size of nanoparticles in pomegranate dye found to be 8.99nm. The proposed solution have been characterized by, UV-Visible spectra and photoluminescence studies. The size of nanoparticles is estimated from Yu model. When CdSe quantum dots are combined with dye, CdSe shows absorption from 387nm to 530nm.These CdSe quantum dot is capable of absorbing more light from sunlight hence will be very useful in increasing the solar efficiency of dye sensitised solar cells.

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