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Green Synthesis and Characterization of CdS Quantum Dots

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Abstract : Our current research involves Cadmium Sulphide (CdS) synthesized by chemical precipitation method using green materials. Papaya peel extract was used as capping agent for the preparation of CdS quantum dots (QD). High Resolution Transmission Electron Microscopy (HRTEM) and X-ray diffraction pattern (XRD) were used to study the morphology, distribution, crystallinity and size. The reports revealed that the CdS QD were formed with cubic phase. The size of the CdS QD was found to be 2.7 nm using Scherrer formula. Existence of blue shift in UV-Vis spectroscopy reveals the formation of nanoparticle.
Keywords : Cadmium Sulphide, quantum dots, HRTEM, XRD, peel extract.

1. Introduction

Semiconductor QD of size less than 10nm has been the subject of extensive research due to their unique size-dependent optical properties and widespread applications in science and technology. Literature reveals high photosensitivity of CdS nanoparticles leading to their utility in the detection of visible radiations, enhancing efficiency of solar cells, as photoconductor in optoelectronic devices in LEDs[1] and a number of biological applications[2].

The size of the semiconductor crystal decreases thereby increasing the band gap between the conduction and the valence bands.[3] Group II-VI semiconductor nanocrystals, such as CdS, CdSe, and CdTe, have been studied widely as they emit in the visible region.[4,5] There is a tremendous effort to improve and control QDs which enable innovations in a broad spectrum of areas including solar cells, light emitting diodes (LEDs), sensors, lasers, medical imaging, and biological labeling.[6-10]

Many research works has been carried out in finding cost-effective and environmental friendly methods.[11] The utilization of biological systems like plant extract, bacteria and fungi has emerged as a novel and reliable method of synthesizing nanoparticles.[11,12] To the best of our knowledge, this is the first study that utilizes Papaya peel extract as capping agent for the synthesis of QDs.

2. Materials and Methods

Papaya peel was used for preparing the extract and the reagents were of high quality and were used without further purification. X-Ray Diffraction (XRD) characterization was performed by means of Shimadzu (Model XRD 6000) diffractometer using Cu Kα radiation. Scanning Electron Microscopy (SEM) images were obtained from JOEL (Model JSM 6390) spectrometer and High Resolution Transmission Electron Microscopy (HRTEM) images from JOEL (Model JEM 2100) HRTEM spectrometer with an accelerating voltage of 200 kV. Elemental analysis was done by Energy Dispersive X-Ray. A UV-VIS spectrum was recorded using Hitachi U2800 spectrophotometer to confirm the band gap.

2.1. Preparation of Papaya Peel Extract

Papaya Peel cut into small pieces was washed with Deionized (DI) water to remove the soil and dust adhered to it. DI water was added to the peel and boiled to 100°C till the volume reduces to half. It is then filtered and used as capping agent.

2.2. Preparation of CdS nanoparticles

CdS (bulk) was prepared by stirring 0.1 N $Cd(NO_3)$ with 0.1N Na_2S using a magnetic stirrer. Initially yellow precipitate and then orange red precipitate was obtained. About 3 g of CdS (bulk) and 50 ml of papaya peel extract were mixed and stimulated using magnetic stirrer for about 18 hours. The yellow coloured CdS nanoparticle formed was then centrifuged, washed with methanol and DI water several times and then dried.

3. Results and Discussions

3.1 XRD analysis

XRD pattern of CdS nanoparticle is shown in Fig 1. 2θ values for the strongest three peaks are 26.5°, 43° and 51° which corresponds to the (1 1 1), (2 2 0) and (3 1 1) planes of the cubic phase of CdS, respectively, according to JCPDS 89 – 0440. CdS nanoparticle formed has cubic symmetry with face-centered lattice having the lattice constant as 5.83A°. The broadness of the peak predicts the formation of smaller sizes. The size of CdS QD crystallite calculated for (1 1 1) plane using Scherrer formula[13, 14] was about 2.7nm.

$$\langle D \rangle = 0.9 \times \lambda / \beta \cos \theta \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where D is the average nanocrystallite size in nm, λ is the X-ray wavelength in nm, β is the full wave half maximum in radian and θ is the Bragg's angle. The results obtained from XRD analysis were tabulated in

Table I: Structural Parameters of CdS Nanoparticle

2θ (deg)	Plane (hkl)	Inter planar Spacing d (A°)	Lattice Constant a (A°)	FWHM (rad)	Average Crystallite Size d (nm)
26.5°	1 1 1	3.35	5.83	2.6676	2.7
43.9°	2 2 0	2.05		3.0583	
51.8°	3 1 1	1.76		3.2000	

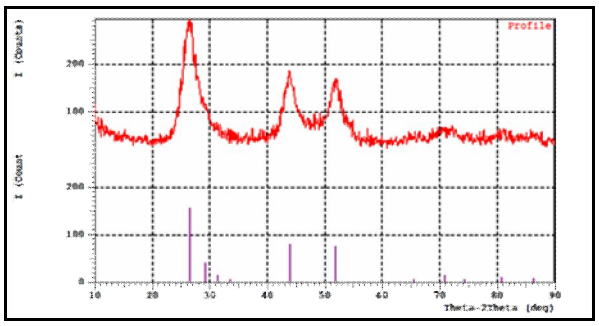

Fig. 1. X-ray diffraction pattern of CdS Nanoparticle

3.2 SEM & EDX Analysis

SEM image was taken for various magnifications and arrived at the agglomeration of the particles and irregularity in the morphology with different sizes (Fig. 2). EDX pattern was shown in Fig.3. The compositional analysis by EDX showed clear peaks of Cadmium (Cd) and Sulphur (S). EDX data is shown in Table II.

Table II: Elemental Composition

Element	App Conc.	Intensity Corrn.	Weight %	Weight % Sigma	Atomic %
S K	29.82	1.0483	21.03	0.48	48.28
Cd K	93.59	0.8759	78.97	0.48	51.72
Total			100.00		

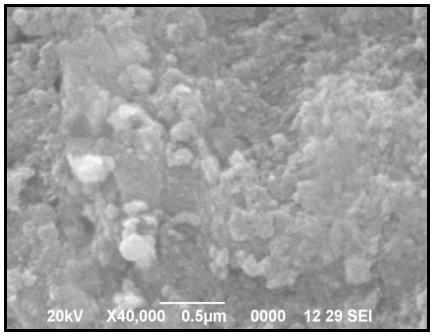

Fig. 2. SEM image of CdS nanoparticle

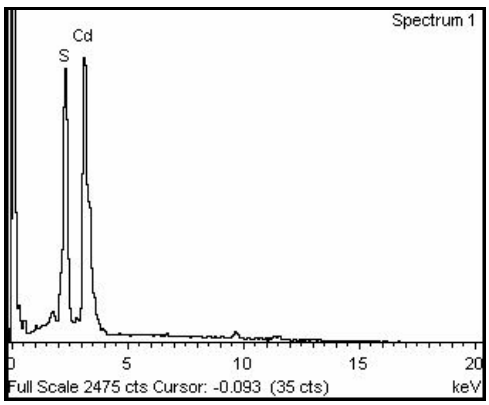

Fig. 3. EDX pattern of CdS Nanoparticle

3.3 HRTEM & SAED Analysis

HRTEM images in Fig. 4 showed that the CdS nanoparticles possess cubic crystalline phase but strongly overlap together. The selected area electron diffraction (SAED) obtained is shown in the Fig. 4b, 4d.

SAED pattern of CdS nanoparticles showed the formation of face-centered cubic structure. The average size of nanoparticle calculated from HRTEM analysis is 2.3 to 3.2 nm that proved the formation of QDs.

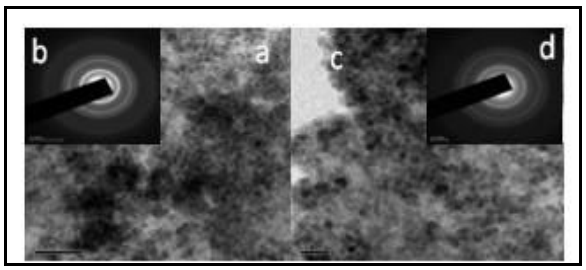

Fig. 4. HRTEM images of CdS QD (a, c) and SAED images of CdS QD (b, d)

3.4 UV-VIS Spectral study

Absorbance spectrum of CdS QD was taken in the range of 200 – 1200 nm (Fig. 5). Cut-off wavelength was obtained from the reflectance spectrum by using UV- Visible spectrophotometer (Fig. 6). The energy band gap E_g measured from the X-intercept of the linear portion of the reflectance as a function of wavelength graph were found to be 2.42 eV for CdS (bulk), 2.45 eV for CdS (QD). The increase in band gap between conduction band and valence band as well as blue shift of the reflectance peak due to quantum confinement provides confirmation of the formation of nanoparticle.

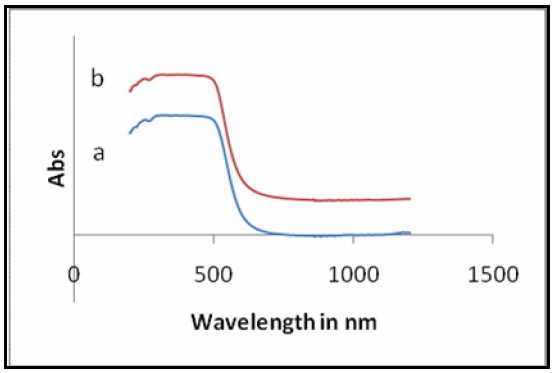

Fig. 5. UV spectra (absorbance) of CdS Bulk (a), CdS nanoparticle (b)

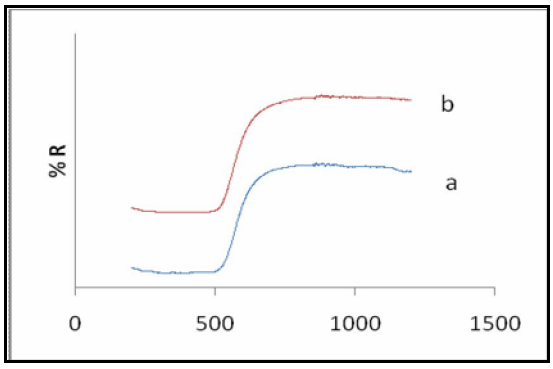

Fig. 6. UV spectra (reflectance) of CdS Bulk (a), CdS QD (b)

4. Conclusion

CdS QDs had been synthesized by green synthesis method using papaya peel extract. The synthesized CdS QDs was characterized by UV, XRD, SEM, HR-TEM. XRD analysis showed the crystalline structure and nano size. From the analysis of UV–Visible spectrophotometer, a blue shift was seen. This method is eco-friendly and does not involve any hazardous and toxic capping agents such as mercaptoaccetate, thiourea, thiophenol, etc. The synthesis of this CdS QD is going to be employed for various applications in the field of solar cells, biomedicine, sensors, optoelectronics and magnetic devices.

References

1. Kawar S.S., Chalcogenide thin films having nanometer grain size for photovoltaic applications, research Journal of Chemical Sciences, 2011, 1(8), 31-35.
2. Gupta M. and Sharma V., Targeted drug delivery system: A, Review, Res. J. Chem. Sci., 2011, 2, 135-138.
3. Brus, L. E. J. Chem. Phys. 1984, 80, 4403.
4. Yu, W. W.; Qu, L. H.; Guo, W. Z.; Peng, X. G. Chem. Mater. 2004, 16, 560.
5. Aldana, J.; Wang, Y. A.; Peng, X. G. J. Am. Chem. Soc. 2001, 123, 8844.
6. Ozkan, M. Drug DiscoVery Today 2004, 9, 1065.
7. Marti, A.; Lopez, N.; Antolin, E.; Canovas, E.; Stanley, C.; Farmer, C.; Cuadra, L.; Luque, A. Thin Solid Films 2006, 511-512, 638.
8. Landi, B. J.; Castro, S. L.; Ruf, H. J.; Evans, C. M.; Bailey, S. G.; Raffaelle, R. P. Solar Energy Mater. Solar Cells 2005, 87, 733.
9. Weng, J. F.; Song, X. T.; Li, L. A.; Qian, H. F.; Chen, K. Y.; Xu, X. M.; Cao, C. X.; Ren, J. C. Talanta 2006, 70, 397.
10. Henini, M.; Bugajski, M. Microelectron. J. 2005, 36, 950.
11. D. Bhattacharya and R. K. Gupta, Crit. Rev. Biotechnol. 2005, 25, 199.
12. D. S. Goodsell, Bionanotechnology: Lessons from Nature (Wiley, Hoboken, NJ, 2004).
13. Brus, L. E. J. Chem. Phys. 1984, 80, 4403.
14. Schmid, G. Nanoparticles: From Theory to Application, 3rd ed.; Wiley-VCH: New York, 2005.

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