

Optical Studies Of Chemically Synthesis CdS Nanoparticles

Rajendra Kumar Duchaniya

Abstract—Cadmium sulphide nanoparticles were synthesized by sol-gel technique. The CdS nanoparticles were characterized using Scanning electron microscope, X-ray diffraction, UV-Vis spectroscopy and FTIR spectroscopy. CdS nanoparticles were found to possess cubic structure with the crystallite size ~ 10 nm. The absorption spectra of synthesized CdS nanoparticles revealed the blue shift in excitonic transitions with respect to CdS bulk material confirm optical studies.

Keywords—XRD, SEM, UV-Visible, FTIR, nanocluster..

I. INTRODUCTION

SEMICONDUCTING optoelectronics materials play functional role in variety of applications due to their extraordinary optical, electrical, magnetic and piezoelectric properties. The Modification of the optical, electrical, magnetic and physical properties of semiconductor materials strictly depend upon the sizes, structures and morphologies [1,2]. Due to these change in properties with the crystallites size researchers interest turn towards the synthesis of semiconductor particle in the few nanometre range with dimensions comparable to the Bohr radius. The semiconductor nanoparticles within the dimension of Bohr radius exhibit strong size dependent properties. Such particles may lead to quantum dot lasers, dot lasers, single electron transistors and also have biological application [3,4]. Cadmium sulphide (CdS) is a II-VI semiconductor material with a direct band gap of 2.42 eV at room temperature with many outstanding optical properties, which have promising applications in multiple technical fields including photochemical catalysis, gas sensor, detectors for laser and infrared, solar cells, non linear optical materials, various luminescence devices, optoelectronic devices and so on[5-8]. Cadmium sulphide has excellent visible light detecting properties among the other semiconductors [9]. In this optical studies, are reported of CdS nanoparticles synthesized by sol-gel technique.

II. EXPERIMENTAL

In this study, cadmium sulphate CdSO_4 used as a Cd^{+2} ion source and sodium sulphide Na_2S as a chalcogen ion S^{-2} source, respectively. For the synthesis of CdS nanoparticles, the 50 ml aqueous solution of (1M) CdSO_4 and 50 ml aqueous solution of (1M) Na_2S were freshly prepared. From these stock solutions, 50 ml of cadmium sulphate and Na_2S were

mixed with EDTA with continuous stirring, till resulted in a cloudy yellow solution. This solution was kept overnight. Later on it was washed with distilled water several times to eliminate the residue molecules. The yellow CdS nanoparticles were obtained after dried in vacuum oven at 60°C for 8 hours followed by filtration. Fig.1 expresses the method for producing CdS nanoparticles with flow chart and Fig.2 shows the CdS nanoparticles produced. The X-ray diffraction (XRD) pattern was recorded using the Panalytical Diffractometer which was operated at 30 KV and 30 mA (Cu K_α irradiation, $\lambda=1.542 \text{ \AA}$). The optical property of nanoparticles was measured using the UV-1800 Spectrophotometer. The IR spectrum was recorded using SHIMADZU FTIR in the range of 400-4500 cm.

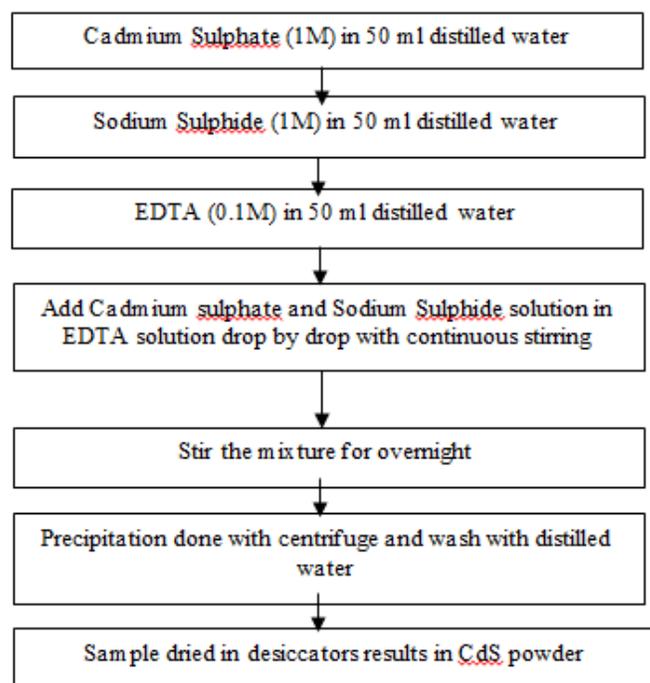


Fig. 1 Flow chart for synthesis of CdS nanoparticle



Fig. 2 Nanoparticles of CdS

Rajendra Kumar Duchaniya is with the Department of Metallurgical and Materials Engineering, Malaviya National Institute of Technology Jaipur Rajasthan-302107, India (Phone no. 09829164784, email: rajyaman15@gmail.com)

III. RESULT AND DISCUSSION

A. Scanning electron microscope

Scanning electron microscope is a suitable technique to study the particle size of materials. SEM image of synthesized CdS nanoparticles are shown in Fig.1. From these SEM image it is noticed that the surface morphologies are in the form of assemblies of nanoparticles having nodular and uniformly distributed over the entire surface observed in Fig.3. The particle size of nanoparticles in SEM image are in range of 10 nm.

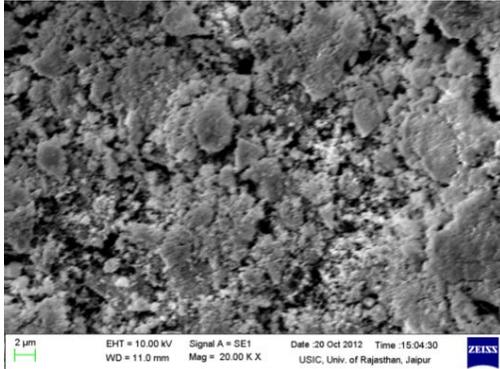


Fig. 3 SEM image of CdS nanoparticles

B. X-ray diffraction analysis

Fig.4 shows the XRD pattern of the as-synthesized CdS nanoparticles. The XRD pattern of CdS has three strong peaks at the angles(2θ) of 26.56° , 43.79° and 52.85° , which could be indexed to diffracting from the (111),(220) and (311) planes, respectively, of the cubic CdS crystal lattice, which is in very good agreement with the international centre for diffraction data (JCPDS card file no.75-1549). From the Full Width at Half Maximum (FWHM) of the most intense peak particle size has been calculated by using the scherer formula.

$$D = 0.9\lambda / \beta \cos\theta$$

where, λ is the wavelength of X-ray diffraction, β is the FWHM in radians of the XRD peak and the θ is the angle of diffraction. The particle size of the sample is found to be 10 nm.

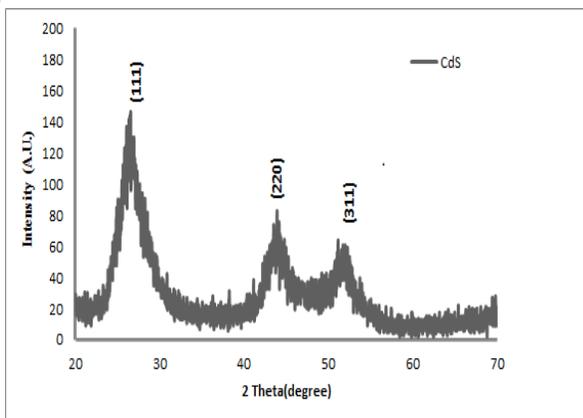


Fig. 4 XRD pattern of cadmium sulphide nanoparticles

C. Optical properties

The UV-Vis absorption spectrum of the CdS nanoparticles is recorded at room temperature as shown in Fig.5. If the absorption peak of the obtained sample appeared blue-shifted

compared with that of bulk CdS, it could indicate the presence of quantum confinement effect. The bulk CdS materials exhibit an absorption peak of about 515nm. Fig.6. shows the Band gap of CdS. As the size of semiconductor particles decrease to nanoscale, the band gap of the semiconductor increases, causing a blue shift in UV-Visible spectra. The bulk CdS materials exhibit a band gap 2.42eV. The grain size of semiconductor particles can be determined using Brus equation [12].

$$E = E_g + \frac{h^2}{8R^2} \left[\frac{1}{m^*_e} + \frac{1}{m^*_h} \right] - \frac{1.8e^2}{4\pi\epsilon_0\epsilon_a R}$$

where E is the onset of absorption of the sample, E_g is the bulk band gap, R is the radius of the particle, m^*_e and m^*_h are the reduced masses of the conduction band electron and valence band hole in units of the electron mass. ϵ_0 is the vacuum permittivity and ϵ_a is the high-frequency dielectric constant. Estimation of particle size of the present CdS sample, using a value of 2.4 eV for E_g gave a value of 5.4 nm. II-IV semiconductor nanoparticles are currently of great interest for their practical applications such as zero-dimensional quantum confined materials in optoelectronics and photonics. Among these, CdS has been studied due to its potential technological applications in field effect transistors, solar cells, photovoltaic, light emitting diodes, photocatalysis, photoluminescence, infrared photodetector, environmental sensors and biological sensors.

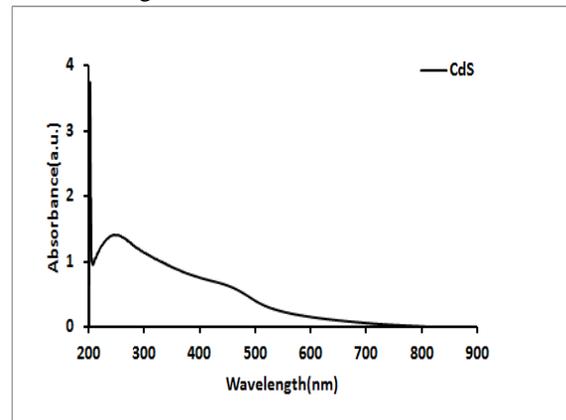


Fig. 5 Absorbance spectrum of cadmium sulphide nanoparticles

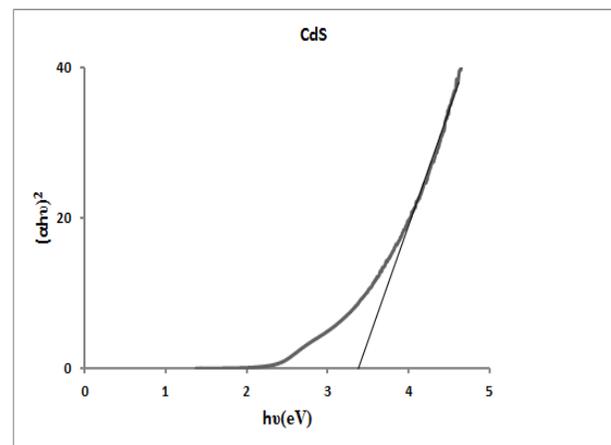


Fig. 6 Determination of Band gap of CdS

D. FT-IR analysis

FTIR spectrum of CdS is shown in Fig.7. In the higher energy region the peak at 3429 cm^{-1} is assigned to O-H stretching of adsorbed water on the surface of CdS. The peak at 1440 cm^{-1} is assigned to bending vibration of methanol used in the process. It is also verified by its CH_3 -stretching vibrations occurring as very weak just below 3000 cm^{-1} . The C-O stretching vibration of adsorbed methanol gives its intense peak at 1117 cm^{-1} . Its ring C-H vibration occurs at about 3000 cm^{-1} , it is a very weak. Similar such weak peaks due to C-H bending vibrations are observed at about 617 cm^{-1} . Hence in addition to adsorbed methanol on the surface of CdS, presence of thiophenol in its dissociation form is also evident. These observations convincingly support template role of thiophenol in the control of the size of CdS particles.

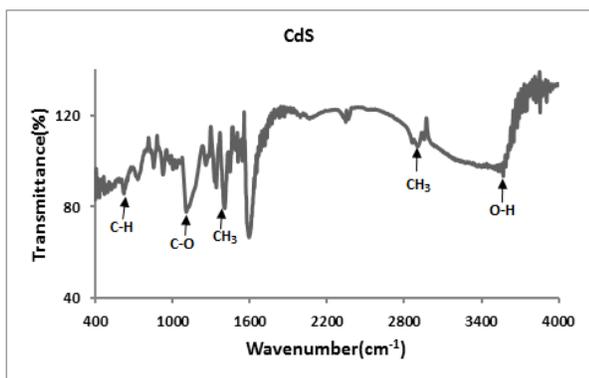


Fig.7 FTIR spectrum of CdS nanoparticles

IV. CONCLUSION

1. CdS nanoparticles were synthesized by sol gel technique and particle size obtained 10 nm.
2. UV-visible absorption spectrum showed a blue-shift indicating quantum confinement of charged particles. Blue shift in band edge of absorption spectrum.
3. SEM is used for microstructure study and to find agglomeration. Nanoparticles show small amount of agglomeration.
4. The presence of template on nanoparticles is confirmed by FTIR technique.

REFERENCES

- [1] Tai G, Zhou J, Guo W Nanotechnology 21(175601):1(2010)
- [2] Hu K, Brust M, Bard AJ Chem Mater 10:1160 (1998)
- [3] Yin Y, Ling X, Ge X, Xia C, Zhang Z Chem Commun 16:1641(1998)
- [4] Chan WCM, Nie SM Science 281:2016 (1998)
- [5] S. Erra S, Shiva Kumar C, Zhao H, Barri K, Morel DL, Frekides CS Thin Solid Films 515:5833 (2007)
- [6] Lakowicz JR, Gryczynski I, Piszczek G, Murphy CJ J Phys Chem B 106(21):5365 (2002)
- [7] Ushakov NM, Yurkov GYu, Zapsis KV, Baranov DA, Kataeva NA, Kosobudskii ID, Gubin SP(2006) Opt Spectrosc 100:414
- [8] Venkatram N, Rao DN, Akundi MA Opt Express 13:867 (2005)
- [9] Ghasemi Y, Peymani P, Afifi S Acta Biomed 80:156 (2006)
- [10] Murray CB, Norris DJ, Bawendi MG J. Am. Chem. Soc. 115, 8706 (1993)
- [11] Wang W, Germanenko I and Samy M El-Shall Chem. Mater. 14, 3028 (2002)
- [12] Brus L J. Phys. Chem. 90, 2555 (1986)