IJRCE

International Journal of

Research in Chemistry and Environment

Available online at: www.ijrce.org

ISSN 2248-9649

Research Paper

Effect of Different Capping Agent on the Preparation and Properties of CdS Nanoparticles by using Starch and Glucose

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(Received 12th May 2015 Accepted 24th August 2015)

Abstract: *In recent years, green synthesis of CdS nanoparticle has attracted a wide attention due to unique properties such as optical and electronic etc. In nature, CdS nanoparticle comes in II-VI group semiconductor and has a band gap of 2.4 eV. It is used in different applications such as Photonics, optoelectronics, biomedical fields, etc. In our work CdS nanoparticles were synthesized using the chemical precipitation method by green chemical route. The CdS nanoparticle were characterized by UV-Visible spectroscopy and X-ray diffraction (XRD) technique used for particle size determination. The particle size is determined by both theoretical and practicle methods. The conductivity measurement is done by TDS/digital conductivity meter. Conductivity of CdS nanoparticles is 0.14 m seimen and 0.04 m seimen by using glucose and starch as a capping agent. It is observed that by the doping the conductivity of nanoparticle increases.*

Keywords: CdS nanoparticle, UV Visible Spectroscopy

Introduction

In recent years, green chemistry has attained great attention in both technical research and in different applications, due to its unique size dependent electronic, optical, structural properties. Semiconductor nanoparticles having size-dependent optical and electronic properties contributed enormously in the development of nanomaterials. In semiconductor nanoparticles the geometry is comparable to the Bohr radius in the bulk, which leads to confinement effect [1]. By enhancing their optical and electronic properties, semiconductor nanoparticles can prove useful in a number of practical applications [2]. Semiconductor nanoparticle belong to II-VI group have excellent optical and electronic properties such as ZnO, CdSe, GaAs, CdS etc. they have direct band gap in the range of 0.3-3.8 eV.

Cadmium Sulphide as a semiconductor material has gained much attention due to its direct band gap develops in the emission in the visible wavelength. Cadmium Sulphide nanostructures widely used for applications in semiconductor laser[3], nonlinear optical devices[4], biological applications[5], display devices[6] and as window materials for hetero-junction solar cells because of its high absorption coefficient[7]. The energy band gap of CdS nanoparticles increases with decreases in size of particles. Transition metal doped is mainly semiconductor and is mainly used because of variety of applications. CdS doped with the transition metal impurities like Co, Ni, Mn etc have great opportunities, which can be used in non-volatile memory devices, spintronic devices [8].

Cadmium Sulphide is a II–VI semiconductor that gives direct band gap energy of 2.4eV (at room temperature)[9]. The Cadmium Sulphide exists in three different types of crystalline structures, they are hexagonal wurtzite, cubic zinc blend and high pressure rock-salt phase. Among these, hexagonal phase is found in both bulk and nano-crystalline phases, whereas the cubic and rock-salt phases can be noticed only in ultrafine, nanosized Cadmium Sulphide system.

A number of techniques used for the synthesis of CdS nanoparticles such as top-down and bottom-up attrition, Laser Ablation, Molecular beam epitaxy, chemical vapour deposition etc

Green chemistry is used for CdS nanoparticles preparation, in which the products design and process use that can reduce the production and use of hazardous substances. It can also define as the process which is favorable over solvent medium. It is not a tool to reduce the effect of hazardous substance but it can also increase the efficiency. In present study, green chemical route using glucose as capping agent at different concentration. The Green chemical route is used because of its non-toxicity and renewability. Method used for synthesis of CdS nanoparticle is chemical precipitation, it is a method in which the formation of solid particles is separated from the solution.

Material and Methods

Materials

Cadmium nitrate (Cd $(NO_3)_2$, Sodium Sulphide (NaS_2), Glucose and starch were used as capping agent, deionized water was used as solvent. All chemicals used were of analytic grade.

Synthesis of Glucose and Starch Capped CdS nanoparticle

Cadmium nitrate, sodium sulfide was added in required amount and was added drop wise and stirred continuously, an orange colour solution is obtained after mixing. The solution is magnetic stirred for 17 hours at 500 RPM. Add 1.8 gm glucose and starch in a different beaker in 100 ml distilled water. Divide the solution in two equal parts and add 10 ml glucose and starch concentration in each solutions drop wise. The sample is then heated and kept in the oven for 7 hours at 100ºC. Filter the precipitates and dried in oven at 70ºC for 6 hours. The same process has to be followed for starch capped CdS nanoparticles for the same condition.

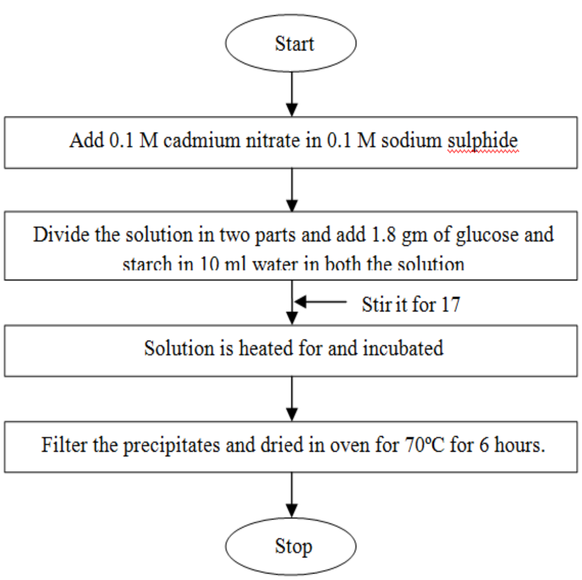


Figure 1: Flow chart of preparation of CdS nanoparticles by using Glucose and Starch as a capping agent

In the preparation of CdS nanoparticle following reaction involve.

$$(Cd(NO)_3)_2 + NaS_2 \xRightarrow{\text{Glucose}} CdS + NaNO_3$$

$$(Cd(NO)_3)_2 + NaS_2 \xRightarrow{\text{Starch}} CdS + NaNO_3$$

Figure 2: CdS nanoparticles a) Glucose capped, b) Starch capped

Results and discussion

UV-VIS spectroscopy

The characterization of CdS nanoparticles was confirmed by determining the optical properties. By UV-Visible spectroscopy the absorption spectrum obtained is coming in a range of 200-800 nm. The maximum absorption wavelength obtained at 3-10 nm confirmed the blue shift as compared to the bulk.

Due to quantum confinement the blue shift is obtained. The direct band gap of CdS nanoparticles is around 2.85 eV and 2.78 eV and particle size obtained is 2.38 nm and 2.62 nm by using glucose and starch as a capping agent respectively. The direct band gap by Ni-doped CdS nanoparticle is 3.31 eV and particle size is 1.66 nm. Due to decrease in size of particle the band gap increases from 2.43 eV to 3.31 eV from bulk to nano.

The average particle size (R) of nanoparticles was estimated using Brus Equation as follows[10]:

$$E = E_g + \frac{\hbar^2\pi^2}{2R^2}\left\{\frac{1}{m_e} + \frac{1}{m_h}\right\} - \frac{1.8e^2}{\varepsilon R}$$

Where E= band gap of synthesized nanoparticle, E_g= bulk band gap of CdS (2.4 eV), R=radius of particle, m_e=effective mass of electron (for CdS, it is $0.20m_o$), m_h= effective mass of hole (for CdS, it is 0.8 m_o), ε = dielectric constant of material and $\hbar = h/2\pi$, where h is Planck's constant.

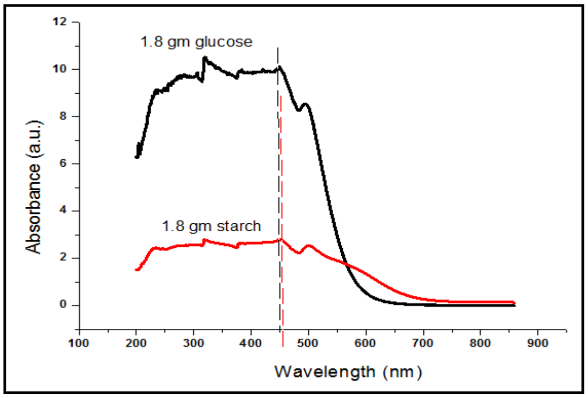


Figure 3: UV-Visible spectrum of Glucose and Starch capped CdS nanoparticle

X-ray diffraction (XRD)

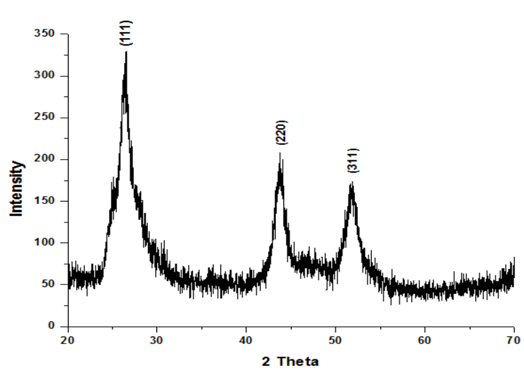
The XRD data for the two samples is taken at the same concentration of capping agent**.** The XRD pattern obtained gives three strong peaks at 26.47 °, 43.75°, 51.85° , whose corresponding planes are (111), (220), (311) respectively for cubic CdS crystal lattices according to JCPDS file No. 75- 1540). The particle size obtained is 3nm from Sherrer equation[11].

$$D = \frac{0.9\,\lambda}{\beta\ \cos(\theta)}$$

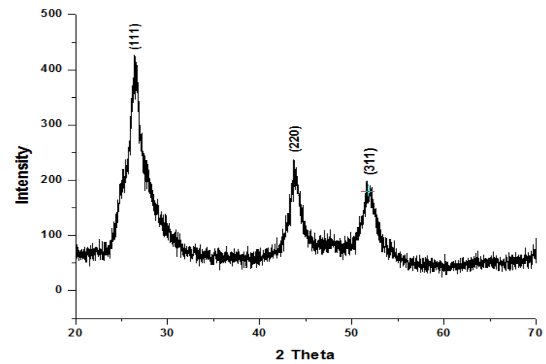
Where, λ is the wavelength of X-ray diffraction, θ is the diffraction angle, β is the full width at half maximum (FWHM) in radian obtained at the most intense peak. The XRD analysis for CdS nanoparticle prepared using glucose and starch is used as a capping agent, exhibit peak at 2θ . Table 1 shows the crystalline size.

Table 1: XRD analysis peaks and crystallite size (nm)

S.No.	Peaks at 2θ	Crystalline phase	FWHM (in degree)	Crystallite size (nm)
1	26.47 °	Cubic	0.0478	2.978
2	43.75°	Cubic	0.0312	4.780
3	51.85°	Cubic	0.0405	3.804



(a)



(b)

Figure 5: XRD pattern of (a) Glucose and (b) Starch Capped CdS nanoparticle

Digital conductivity meter

The conductivity measurement is done by TDS/digital conductivity meter. Conductivity of CdS nanoparticles is 0.14 m seimen and 0.04 m seimen by using glucose and starch as a capping agent. It is observed that by doping the conductivity of nanoparticle increases. Table 2 shows the conductivity of two different samples.

Table 2: Conductivity of different sample

CdS nanoparticles	Conductivity (m seimen)
Glucose (1.8 gm)	0.17
Starch (1.8 gm)	0.04

Results and discussion

The UV-Vis absorption spectrum of CdS nanoparticles is obtained at room temperature. The absorption peaks obtained confirms the blue shift when compared to the bulk material this is because of quantum confinement effect. The bulk CdS has exhibit direct band gap of 2.42 eV. The grain size of CdS nanoparticle is determined by effective mass approximation formula. By X-ray diffraction measurements it is conformed that particle size is in nanometer range and crystal structure of prepared particle is cubic is confirmed by the planes.

Conclusion

A simple chemical method is used for the synthesis of CdS nanoparticle by using glucose and starch as a capping agent. This method is eco-friendly, it does not involve the use of hazardous and toxic capping agent such as thiophenol, thioglycerol, and thiourea. Further, the capping agent was significantly affected the crystalline size and a blue shift obtained at λ_{max}.

References

1.Duchaniya Rajendra Kumar, Optical Studies Of Chemically Synthesis CdS Nanoparticles, *International Journal of M, Mining, Metallurgy & Mechanical Engineering*, 2(2), (2014) 2.Bansal P., Jaggi N. and Rohilla S.K., *Research J. of chm. science*, **2(8)**, **(2012)**

3.Dunan et al., Single-nanowire electrically driven lasers, *Nature,* **421**,**(2003)**

4.Grohs et al., Noise-induced switching and stochastic resonance in optically nonlinear CdScrystals, *Phys. Rev. A,* **49, (1994)**

5.Santos et al., Semiconductornanocrystal obtained by colloidal chemistry for biological application, *Appl. Surf. Sci.*, **255, (2000)**

6. Schmitt-Rink et al., Linear and nonlinear optical properties of semiconductor quantum wells, *Adv. Phys.,* **38, (1989)**

7. Xiaoxia et al., Template-free synthesis of vertically aligned CdSnanoroads and its application in hybrid solar cells,Sol. Energy Mater, *Sol. Energy Mater. Sol. Cells,* **94**, **(2010)**

8.Oh E., Choi J.H., Oh D.K. and Park J., Magnetophotoluminescence and energy-dependent circular polarization from CdMnS nanowires, *Appl. Phys. Lett*., **93**, **(2008)**

9. Alivisatos A.P., Semiconductor clusters, nanocrystals, and quantum dots, *Science,* **271**, **(1996)**

10. Brus L., Electron-Hole Recombination Emmision as a Probe of Surface, *J. Phys. Chem.*, **90**, 2555 **(1986)**

11. Cullity B., Handbook of Elements of X-ray Diffraction, 2nd ed., Addison-Wesley, Reading, MA, **(1978)**.