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Research Paper

Synthesis and Characterization of CdS Nanoparticle and Measurement of Conductivity of Different Sample

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***Abstract**: The Cadmium Sulphide nanoparticle is a semiconductor material belongs to the group II-VI, having a direct band gap of 2.42 eV. CdS is a versatile material with unique properties like optical, electronic, thermal, etc, it has a wide range of applications in sensors, biomedical devices, light emitting devices, etc, in the present work, the preparation of CdS nanoparticles were done by using chemical precipitation and green chemical route and characterization are done through UV-Visible spectroscopy is used for particle size determination obtained around 3-10 nm and FTIR is used for identification of compounds by matching spectrum of a sample compound. The measurement of conductivity is done by TDS digital meter.*

Keywords: *CdS, Nanoparticles, UV-Visible spectroscopy*

Introduction

Nanoscience and nanotechnology have evolved as the most interesting field of research and have gained much importance in the few years. Their physical size gives them greater surface area to volume ratio that results into higher chemical activity, greater surface plasmon resonance (SPR), enhanced Rayleigh scattering and surface enhanced Raman Scattering as compared to their bulk material. There are widespread nanoparticle applications, some of which include signal reporters to detect various biomolecules in immunoassay, as flurophore in fluorescence[1], treatment of diseases like for detection of cancer, bioimaging of cell, fabrication of scaffolds for joints, delivering drugs[2]. Among various nanoparticles, cadmium sulphide (Cadmium Sulphide) nanoparticles attract the attention of researchers because of some specific properties such as availability of discrete energy levels, tunable band gap, size dependent optical properties. Mainly the cadmium compounds are stable[3].

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[4]. By enhancing their optical and electronic properties, semiconductor nanoparticles can prove useful in a number of practical applications.

Semiconductor nanoparticles have a variety of applications due to its quantum confinement effect[5]. As reducing the size of the particles the modification of the properties results that gives unique piezoelectric, optical, electronics, physical properties done by varying the particle size[6]. The semiconductor nanoparticles exhibit strong size dependent properties when the dimension is comparable with the Bohr radius. This type of semiconductor nanoparticles can be used in a single electron transistor, dot laser etc[7]. Semiconductor belongs to II-VI group have direct band gap. Semiconductor was registered as their properties differ from the bulk semiconductors. In case when materials are present in bulk, the energy levels of electrons are different. Materials that are considered as semiconductors typically have band gaps in the range of 0.3-3.8eV. The energy is close to each other and they are described as continuous. The band gaps for some of the materials are fixed. This means that addition of atoms would hardly be distinguishable and hence it won't make a measurable difference to the band gap.

In semiconductors, optical absorption process may be accomplished if the energy of photon incident on the semiconductor is greater than its band gap. If this condition is satisfied an electron-hole pair is generated, which is allowed to move freely away from one another. This random motion of charge carriers results into electrical conductivity within the semiconductor.

Cadmium Sulphide is a semiconductor material has gained much attention due to its direct band gap develops in the emission of visible wavelength. Cadmium Sulphide is a II–VI group semiconductor that has direct band gap energy of 2.4 eV. Cadmium Sulphide is a semiconductor that generates great interest due to its unique chemical and physical properties that depends on size[8]. Researchers have mainly focused on the synthesis of various nanostructures of cadmium sulphide. Cadmium sulphide is a versatile material and used in photochemical catalysis, solar cells, non-linear optical materials and many luminescence devices[9]. In the present work, the characterization is done through UV-visible spectroscopy and conductivity is measured through TDS meter and particle size is estimated through effective mass approximation formula.

Material and Methods

Materials: Cadmium nitrate ($Cd(NO_3)_2$, Sodium Sulphide (NaS_2), EDTA, Ni-acetate, methanol, thioglycerol and deionized water were used as solvent. All chemicals used were of analytic grade.

Synthesis of EDTA Capped CdS nanoparticle

In our present work, cadmium nitrate is used for utilizing the cadmium ions, sodium sulphide is used for utilizing the sulphide ions and both were mixed at certain amount in 100 ml distilled water. Now add both the solutions drop wise and then stirred continuously, after mixing an orange colour solution is obtained. Add EDTA and magnetic stir for 17 hours at 500 rpm and kept it in oven for 7 hours at 100ºC. Filter the precipitates and dried in oven at 70ºC for 6 hours.

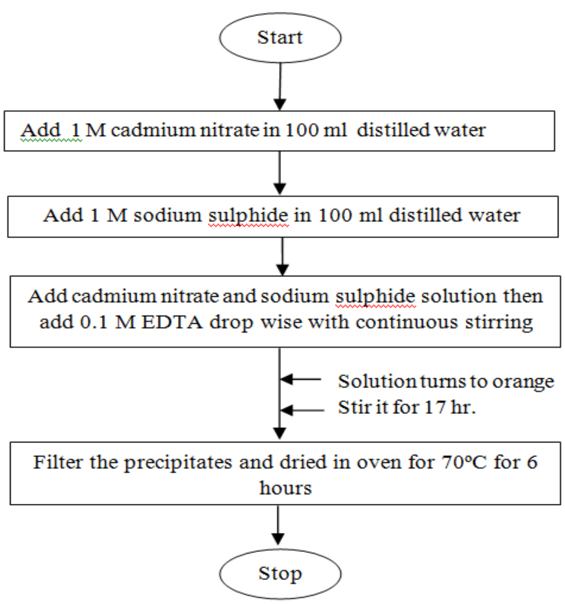

Figure 1: Flow chart for preparation of EDTA capped CdS nanoparticles

Synthesis of Ni-doped CdS nanoparticle

Add 0.1 M sodium sulphide in 50 ml distilled water and add 100 ml methanol and 1.1 ml thioglycerol. Take 1M cadmium nitrate in 100 ml methanol and add it to 2% weight of Ni-acetate to this solution. Now add both the solution and the colour turns to the dark brown. Now stir the solution for 16 hours and the solution colour obtained is yellow. Filter the solution and wash with methanol. Now heat the filter precipitates in oven for 7 hours.

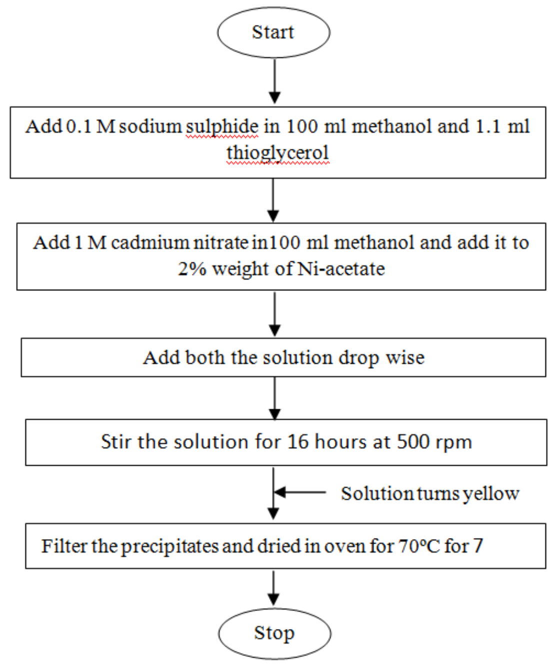

Figure 2: Flow chart for synthesis of Ni-doped of CdS nanoparticle

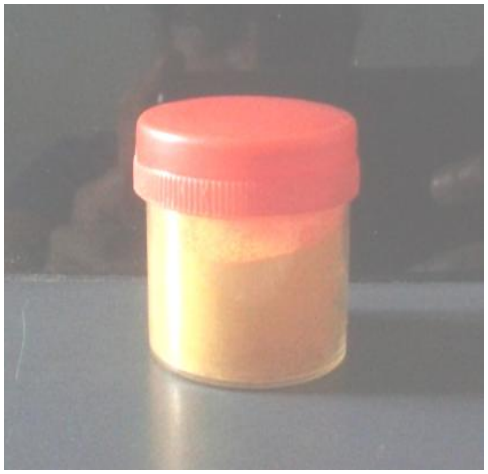

Figure 3: CdS nanoparticles

Characterization

The characterization is done by using UV-Visible spectroscopy and particle size is determined through the effective mass approximation formula, that shows the presence of nanoparticles having size of 3-10nm.

Results and Discussion

A. UV-Visible spectroscopy

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 bulks CdS have an exhibit direct band gap of 2.42 eV. The grain size of CdS nanoparticle is determined by effective mass approximation formula[10].

$$E_n = E_g + \frac{h^2}{8R^2}\left[\frac{1}{m_e^*} + \frac{1}{m_h^*}\right] - \frac{1.8e^2}{4\pi\epsilon_o\varepsilon_a}$$

Where, E_n is the band gap of nanoparticle, E_g is the band gap of bulk nanoparticle, m_e^* and m_h^* is the reduced mass of elelctron and hole. ϵ_o is the permittivity of free space and ε_a is material dielectric constant. R is the radius of the nanoparticle.

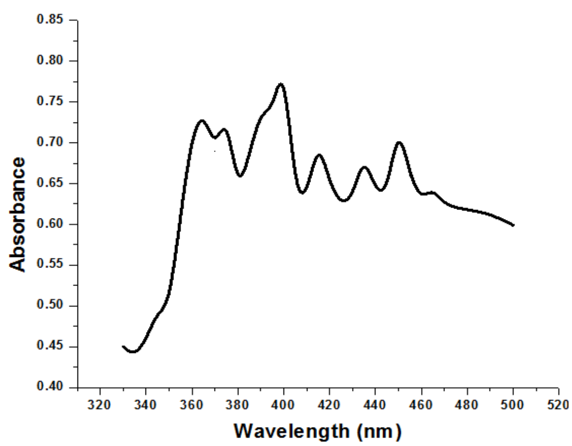

Figure 4: UV-Visible spectrum of EDTA Capped CdS nanoparticle

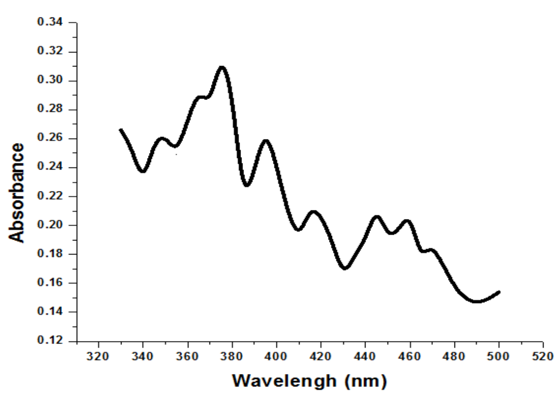

Figure 5: UV-Visible spectrum of Ni-doped CdS nanoparticle

Fourier transform infrared (FTIR) spectroscopy

FTIR spectrum of CdS is shown in Fig. 6 the higher energy peak region 3465 cm^{-1} is defined for O-H shows the stretching of water that absorbed on the surface of CdS. At the peak 1587 the presence of water is confirmed by bending. cm^{-1}. The CH_3-stretching occurs below 3000 cm^{-1} and C-O stretching vibration obtained at 1113 cm^{-1}. In Figure 7, the dislocation is due to addition of methanol and thioglycerol. The peak 1388 shows the bending vibration of methanol.

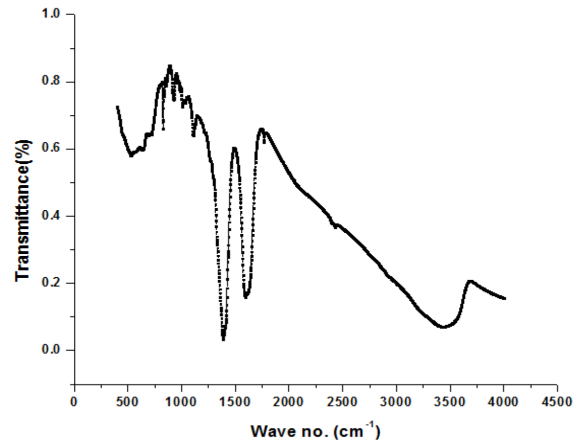

Figure 6: FTIR spectrum of EDTA Capped CdS nanoparticle

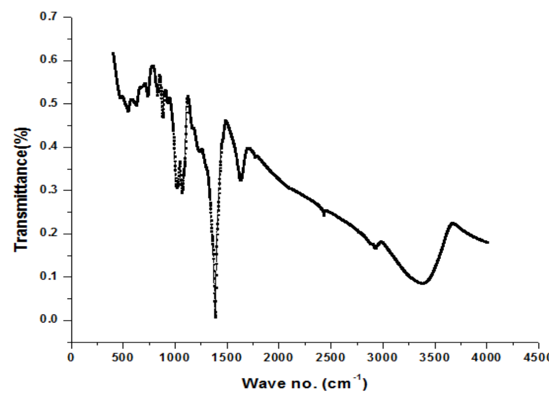

Figure 7: FTIR spectrum of Ni-doped CdS nanoparticle

Digital conductivity/TDS meter

The conductivity shown by CdS nanoparticle prepared by using EDTA is 1.24 m seimens and for Ni-doped CdS nanoparticles it is 0.68 m seimens. Table 1 shows the conductivity of different sample.

Table 1: Conductivity of different sample

CdS nanoparticle sample	Conductivity (m seimen)
EDTA capped	1.24
Ni-doped	0.68

Conclusion

CdS nanoparticles were synthesized successfully using the chemical precipitation method by chemical and green route. In the present study the particle size obtained by EDTA capped CdS nanopartcle is 1.88 nm and Murraya Koeniggi leaf extract capped CdS nanoparticles is 1.79 nm.

Acknowledgement

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