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Research Paper

Tailoring of CdSe Nanoparticles by Different Techniques

Physics

KEYWORDS : Nanoparticles, Chemical synthesis, X- ray diffraction, Scanning electron microscopy, Ultrasound.

I. Johnson	Centre for Nano Science and Applied Thermodynamics, Department of Physics, St.Joseph's College (Autonomous), Trichy-620002, India
H. Joy Prabu	Centre for Nano Science and Applied Thermodynamics, Department of Physics, St.Joseph's College (Autonomous), Trichy-620002, India
C. Bhagya Lakshmi	Centre for Nano Science and Applied Thermodynamics, Department of Physics, St.Joseph's College (Autonomous), Trichy-620002, India
S. Arulappan	Centre for Nano Science and Applied Thermodynamics, Department of Physics, St.Joseph's College (Autonomous), Trichy-620002, India

ABSTRACT

Nanocrystalline cadmium selenide (CdSe) is a low bandgap material (Eg = 1.75 eV, at room temperature). II-VI semiconductor nanoparticles are presently of great interest for their practical applications in zero-dimensional quantum confined materials and for their applications in optoelectronics and photonics. In the present work, we have synthesized nanoparticles of CdSe using chemical method. Particle size has been reduced effectively by Ultrasound technique. This chemical method is very facile, inexpensive and less hazardous and ensures almost complete yield of the precursors while Ultrasound method yields finer particles. The CdSe nanoparticles were well characterized by powder X- ray diffraction (XRD) and Scanning electron microscopy (SEM). It is investigated that as synthesized powder has a hexagonal structure of CdSe with diameters of the particles in the range of 6-20 nm

INTRODUCTION

Nanocrystals are interesting because they exhibit unique properties depending on their size. CdSe is a semiconducting material whose energy bandgap is in the visible region (~650 nm) [1, 2]. When these particles are made very small, quantum confinement produces a range of different colors depending on the size of the particle [3]. The origin of this effect is due to the size of the particle which becomes smaller than the size of the charge carriers (which are responsible for light emission)[4]. Nanoparticles and nanostructural materials are central to fundamental studies, applications in nanoscience and nanotechnology, due to their novel electronic luminescent and magnetic properties that are not present in the bulk forms. Among the various nanostructural materials, Cadmium Selenide and other II–VI compound semiconductors are important for optoelectronic materials, which have been intensively studied due to their applications in light-emitting diodes, catalysis, solar cells and biomedical labeling [5,6]. A variety of methods has been employed to synthesize CdSe nanoparticles in recent years. But this chemical method is suitable for preparing nanoparticles.

Chemical method is simple and environmental friendly technique for synthesis of CdSe nanoparticles. It leads to production of nanoparticles with high quality (a narrow size distribution and a high quantum yield) and desired sizes.

The present study tries to satisfy all of these requirements to the large-scale production of CdSe nanoparticles. The synthesized nanoparticles were subjected to powder X-ray diffraction to check the crystalline structure, lattice parameters and to calculate the crystallite size. The scanning electron microscopy study (SEM) was used to determine the particle size and shape (by chemical synthesis and Ultrasound influence).

MATERIALS AND METHODS

2.1. Materials

Cadmium selenide (CdSe) is a solid, binary compound of cadmium and selenium (a very rare mineral). [7, 8]

The high quality Cadmium and Selenium powders (SIGMA ALDRICH) were used for the synthesis of CdSe nanoparticles. Hexane, Methanol, Pyridine was used as purchased from Aldrich. All chemicals were used directly without any further purification.

2.2. Synthesis of CdSe nanoparticles

The prepared CdSe powder (99.9%) of 1.91 gram has been taken and 25ml of Hexane is added. And this was put under a vigorous magnet stirring rotation process at the range of 200 -250 rpm for 3 hours and above at 85°c temperature.

Once the Hexane gets evaporated and the sample is taken away very carefully from the magnetic stirrer since the size of the particles are very minute and it could be easily blown away or dropped. The sample is kept in a quiet place to get settled down and to reduce its temperature. Once the temperature is reduced, the sample is filtered.

2.3. Filtering Process of CdSe nanoparticles

The filtering process starts with adding 20 mL of Methanol with the sample of Cadmium Selenide (CdSe) and the solution has been filtered by using 0.2 micrometer PTFE filter paper. This is repeated for two times. A sufficient amount of Pyridine is added for further purification process and it is filtered again as we have done above. In order to get a purified powder, a small amount of acetone is added and then filtered again and again many times. At last the powder is collected in Petri dish.

2.4. X-ray powder diffraction

X Ray Diffraction was performed by using Rigaku Miniflex X ray diffractometer which utilized CuKα (1.54 Å) as target material [9]. XRD data were used to determine the lattice parameter, crystallite size and phase identification.

Crystallite size was calculated by applying Sherrer's equation [10, 11].

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

Where, d is the crystalline size, λ is the wavelength of the CuKα (1.54 Aº), θ is the angle between the incident beam and the reflecting lattice plane and β is the full width at half maxima (FWHM) of the diffraction peak (in radian) [12].

2.5. Scanning electron microscope

The scanning electron microscope (SEM) has been used to find out the morphology and size of the synthesized nanoparticles of the

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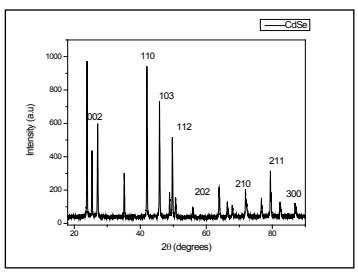
CdSe material. The CdSe powder was dried in vacuum using rotary evaporator [13].

3. RESULTS AND DISCUSSION

The black CdSe nanoparticles obtained after the completion of reaction were characterized by various techniques to investigate their particle size and structural features. The Cadmium Selenide (CdSe) nanoparticle was prepared by chemical method and the powder was dried by using hot air oven (300°c).

Figure 1: X-ray diffraction pattern of CdSe



X-ray diffraction pattern of the prepared CdSe sample is shown in Fig. 1. The XRD measurements of CdSe nanoparticles shows that the position of several diffracted peaks match well with the standard powder diffraction data (a = 4.299 Å and c = 7.010 Å). The several peaks of CdSe have been obtained due to diffraction form (002), (110), (103), (112), (202), (210), (211), and (300) planes of Hexagonal (Wurtzite) CdSe which are in very good agreement with hexagonal structure (Joint Committee on Powder Diffraction Standards) JCPDS CAS No. 77-2307.

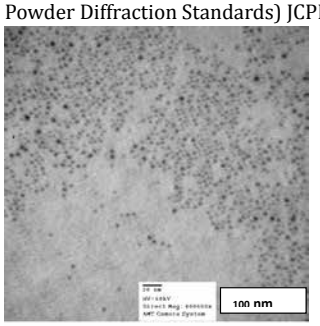


Figure 2: SEM micrograph for CdSe nanoparticles 2 rounds of reduction.

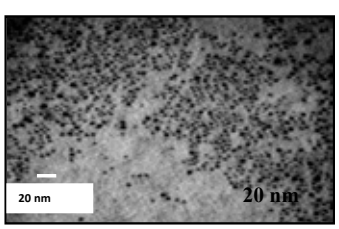


Figure 3: SEM micrograph for CdSe nanoparticles (after Ultrasouvd irradiation -final).

The Scanning electron microscopy (SEM) image of the CdSe nanoparticles at here stages have been shown in Figs. 2 and 3. The surface morphology of Cadmium Selenide (CdSe) was studied by SEM technique that shows that these materials are polycrystalline in nature. Particle sizes are found to have a range of 6 to 20 nm.

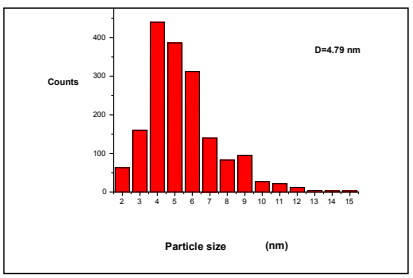


Figure 4: The Spectral band observation of CdSe nanoparticles

4. CONCLUSIONS

In summary, hexagonal CdSe nanoparticles have been successfully synthesized using a novel Chemical method at room temperature. The average grain size of the sample is determined to be ~5.33 nm from the full width at half maximum of the most intense peak making use of the Scherrer's equation, Powder X-ray diffractogram shows that ZnSe nanocrystallites are polycrystalline in nature and belong to the hexagonal phase. The particle size obtained by SEM was ~3.69 nm. Ultrasound technique for size reduction of toxic CdSe nanoparticles is found to be less hazardous and environmental friendly technique than other techniques found in the literature.

5. ACKNOWLEDGEMENT

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