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Structural, optical and morphological characterization of Zinc Selenide Nanoparticles synthesized by Solvothermal method

P.Raji

Department of Physics, Mepco Schlenk Engineering College, Sivakasi- 626005

Abstract

Zinc Selenide nanoparticles were synthesized via solvothermal method using zinc chloride and selenium powder. X-ray diffraction (XRD), Scanning Electron Microscope (SEM), Ultraviolet – Visible spectroscopy and Photoluminescence Spectroscopy were used to analyze the sample. XRD confirmed the cubic zinc blende phase and the mean size of the particle was determined using Scherrer formula was 65nm. SEM image revealed the spherical shape of the particles. Photoluminescence spectra with excitation wavelength (325nm) show a weak emission peak at 555nm.

Key Words: *ZnSe ,SEM, UV – Vis, XRD*

1.INTRODUCTION

Zinc and selenium combine to form zinc selenide (ZnSe), a binary chemical. Because of its special qualities, this material is highly valued in a wide range of industrial and technological applications [1-6]. With a direct bandgap of 2.7 eV, ZnSe is a wide-bandgap semiconductor with exceptional optical characteristics [8]. It is a great option for use in optical devices including lenses, windows, and infrared lasers because of its excellent transparency over a broad range of wavelengths, from visible to infrared.

Zinc selenide are used in semiconductor devices such as photodetectors, light-emitting diodes (LEDs), and laser diodes, in addition to its optical uses [9-11]. These uses stem from its capacity to promote effective electron-hole pair production and recombination.

ZnSe is also well-known for having strong thermal conductivity and chemical stability, which improve its performance and endurance in high-temperature and high-power settings. Thanks to these properties, it is an essential material for a wide range of applications in industry and research, from electronics to photonics and beyond. Zinc selenide significance and adaptability in contemporary science and engineering are shown by the ongoing research that aims to further investigate and broaden its possible applications. This is especially true for developing technologies like quantum computing and sophisticated imaging systems.

Sol gel [12], co precipitation [13], the hydrothermal route [14], the solvothermal route [15], the sonochemical approach [16], thermal treatment [17], and colloidal synthesis [18] are some of the techniques that can be used to produce ZnSe nanoparticles . Of them, the solvothermal method's simplicity, speed, and affordability make it ideal for producing nanoparticles on a wide scale.

The solvothermal synthesis of ZnSe nanoparticles and their structural, optical, and morphological characteristics were investigated in this work.

2. EXPERIMENTAL SECTION

The primary chemicals utilized are ethylene glycol, elemental selenium, zinc chloride ($ZnCl_2$), and hydrazine monohydrate, all of which are acquired from MERCK. All compounds were utilized without any additional processing. The experiment utilized deionized water.

During the synthesis process, a 100 ml conical flask containing 4 gm of zinc chloride and 2 gm of elemental selenium was filled with deionized water, ethylene glycol, and hydrazine hydrate in a volume ratio of 5:3:2. The solution was then refluxed for five hours at 70°C. After gathering the black precipitates, they were repeatedly cleaned with hot distilled water and anhydrous ethanol before being calcined for two hours at 700°C.Zinc selenide nanoparticles were thus produced.

3.CHARACTERIZATION

ZnSe nanoparticles' X-ray diffraction pattern was captured using a PAnalytical X'Pert PRO diffractometer under Cu-Kα radiation (wavelength: 1.54Å). With the use of a scanning electron microscope (Model: SU150-HITACHI), the sample's morphology was assessed.UV-Vis

Spectrophotometer (Shimadzu, Japan) was used to record UV-Visible spectra in the 200–800 nm wavelength range. A spectrofluorimeter (F-2500 FL Spectrophotometer, Hitachi) was used to measure the photoluminescence (PL) spectrum of the nanoparticles.

4.RESULTS AND DISCUSSION

4.1 X – Ray Diffraction*:*

Good crystallinity of the zinc selenide nanoparticles is shown by the peaks in the XRD pattern; no distinctive peaks of any other phase of ZnSe were seen. The synthetic materials were identified as ZnSe by X-ray diffraction experiments, and all of the diffraction peaks matched those of cubic zinc blende phase [19] of ZnSe.

The Debye – Scherrer is given by,

$$d = \frac{k\lambda}{\beta \cos\theta} \quad (1)$$

Where, K is a shape constant (0.89), λ is the wavelength of X-ray (0.1540 nm), β is the full width at half maximum and θ is the angle of diffraction. The Debye-Scherrer formula is used to determine the average crystal size, which comes out to be 69 nm.

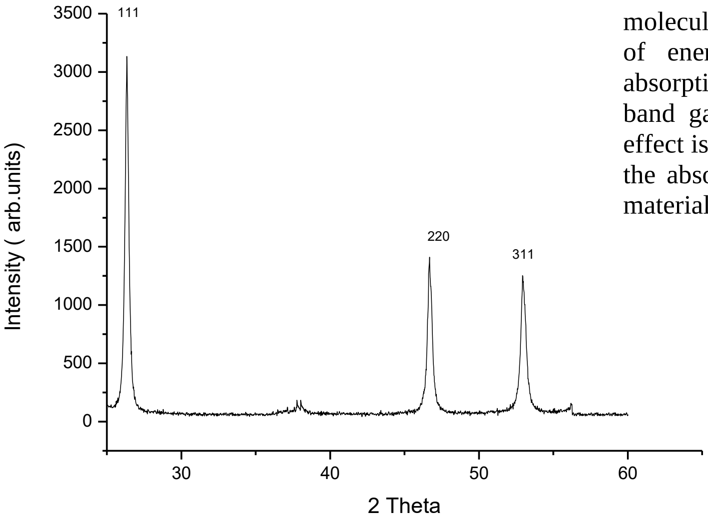

Fig:1 XRD pattern for ZnSe nanoparticles

4.2 Scanning Electron Microscopy

Images are captured using Scanning Electron Microscopy for the obtained nanoparticles of zinc selenide. The scanning electron microscope was used to examine the zinc selenide nanoparticles' crystalline size. The crystals' forms were similar to spheres [20].

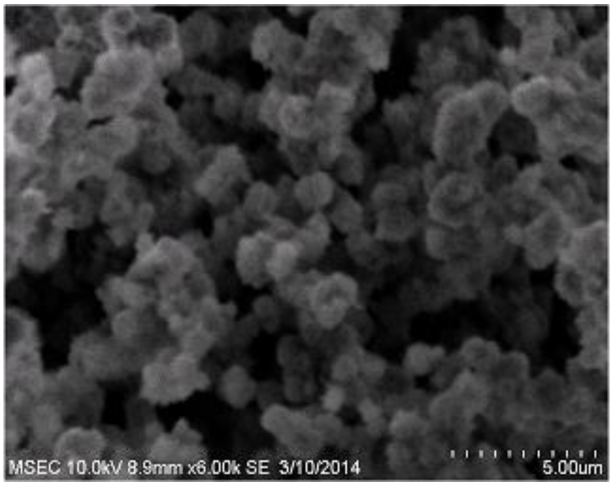

Fig:2 SEM image of ZnSe nanoparticles

4.3 UV – Visible Spectroscopy

The basis of Ultra Violet-Visible Spectroscopy is the light absorbance or reflectance of the nanoparticles in the regions affected by Ultra Violet-Visible radiation. Utilizing the principle of absorption of ultraviolet or visible light to excite non-bonding electrons (n-electrons) to higher anti-bonding molecular orbitals, molecules harboring these electrons can be the source of energy employed in this spectroscopy. The absorption edge is located at 384 nm [21], and the band gap is at 3.3 eV. The quantum confinement effect is thought to be responsible for the blue shift in the absorption peak when compared to that of bulk material (460 nm, 2.7 eV).

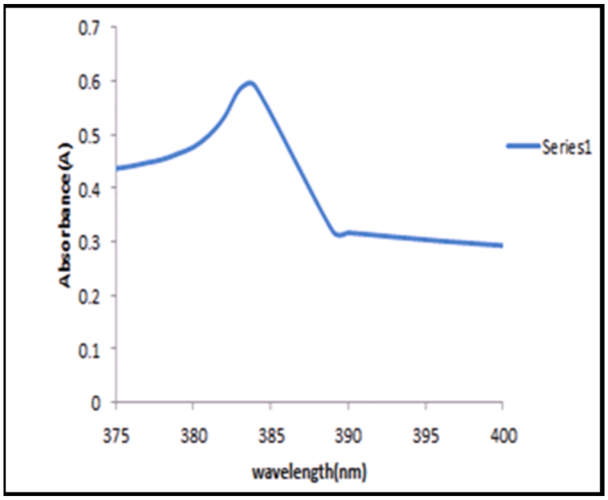

Fig:3 Absorption specta of ZnSe nanoparticles

4.4 Photoluminescence spectroscopy:

The broad band emission observed in photoluminescence spectroscopy [22] between 500 and 600 nm is caused by deep level emission at an excitation angle of 385 nm. The bulk ZnSe is detected at 465 nm, while the emission peak is found at 554 nm.

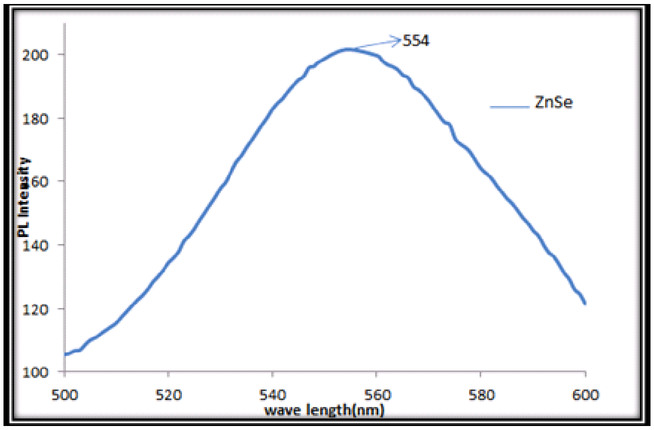

Fig:4 Photoluminescence spectra of ZnSe nanoparticles

5.CONCLUSIONS

In conclusion, almost monodispersed ZnSe nanoparticles free of any hazardous ingredient, surfactant, or template were effectively synthesized in an aqueous solution of hydrazine hydrate and ethylene glycol at 90°C in about five hours. When describing the ZnSe nanoparticle, XRD provides the nanoparticle's size. When comparing ZnSe nanoparticles to bulk ZnSe, which is seen at 460 nm, the absorption spectra reveal a blue shift in the absorption edge at 375 nm. The ZnSe nanoparticles' spherical form is visible in the SEM image. ZnSe nanoparticle photoluminescence spectra exhibit a red shift at 554 nm compared to 465 nm for bulk ZnSe. This method's benefits include its simplicity, low cost, efficiency, and economy, all of which occur quickly.

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