Morphological and Electrical Properties of Capped CdSe Nanoparticles

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Abstract In this study, cadmium selenide (CdSe) were synthesized by a chemical route process using complex agent (tri sodium citrate) as a ligand, cadmium acetate as a Cd source and Na2SeO3 as a Se precursor. The synthesized nanoparticles were characterized for their compositional, morphological and electrical properties using FESEM, EDAX and I-V characterization.

1. Introduction
Due to their unique structural, optical and electronic transport characteristics resulting from the quantum containment of electrons, nanostructured semiconductors have drawn extensive attention. They are structurally, morphologically, optically and electrically dependent on size[1]

High quality, stability and reliability of semiconductors remains a challenge, posing severe barriers for their use for practical need. High quality II–VI semiconductors with controlled defects and impurities are needed in electronic and optoelectronic applications[2]

Because of their prospective uses in many applications, much attention has been paid to II – VI materials. Binary metal chalcogenides synthesis of group II – VI semiconductors in the form of nanoparticles was a quickly increasing area of studies due to their significant nonlinear optical characteristics, luminescent properties, quantum-size effects and other significant physical and chemical characteristics[3]. All these properties are size dependent

Nanoparticles’ size control remains a key method for successfully applying nanotechnologies. Understanding of the role of the capping agent, because of surfactant adsorption on the surface of the particulate, is essential for the growth of regulated synthesis of nanoparticles, preventing nanoparticles from being aggregated. A adequate knowledge of the role of surfactants can allow the control by various surfactants of particle size[4,5].

NCs consist of an inorganic core stabilized in ligands with a layer of organic molecules and the resulting inorganic hybrid provides versatility and flexibility in the processing and surface engineering of solutions. The characteristics can therefore be modified by playing with the organic surfactant layer to manipulation of surface chemistry[6].

The nanocrystal size is regulated by the adsorption of longchain surfactants, capsule materials to the surface of nanocrystals, forming inverse structures of micelles[7]

Aqueous synthesis do not require any special equipment or high temperature. Bare synthesized NPs are very unstable, highly reactive which results in photochemical degradation. Therefore a stabilizer or surfactant is required to synthesize stable and prevent aggregation of NPs and can be further used for conjugation or various applications. The stabilizer also helps in controlling the size of NPs[8]
Cadmium selenide is a classic II-VI semiconductor with a direct Eg of 1.74 eV[9]. It is photosensitive in visible wavelength regions due to its suitable Eg. It is widely used in solar cells[10] as well as photoelectrochemical cells[11]

in this paper we study the electrical and morphological properties of CdSe capped with TSC nanoparticles.

2. Experimental

2.1 CdSe Nanoparticles Preparation

The procedure of CdSe-TSC NPs. preparation, optical and structural properties had been discussed in our paper[12].

3. Results and discussions

The surface morphology of TSC capped CdSe thin films was analyzed by using a Scanning Electron Microscope (SEM). SEM is a suitable and useful technique to study and analyze the surface morphology of thin films.

The surface morphology of CdSe-TSC is shown in Figure 1 shows that the surface is smooth and has spherically shaped grains. The surface is covered with uniformly size grains. No cracks or holes are observed in the thin films. The mean grain sizes of films were about 30 nm.

![FESEM images of CdSe-TSC nanoparticles](image)

**Figure 1.** FESEM images of CdSe-TSC nanoparticles

EDX measurements were performed on the sample to study the chemical composition. Figure 2 shows an EDX spectrum for the illustrative CdSe-TSC NPs. The EDX form confirms the existence of cadmium and selenium in the compound. It also displays that the ratio of Cd and Se is 54.18 and 21.67, respectively.
Figure 2. EDX analysis of CdSe-TSC nanoparticles.

Figure 3 gives the FTIR spectrum in the frequency range (500–4000 cm\(^{-1}\)) of TSC and CdSe-TSC. The observed band positions in the spectra of TSC capped CdSe match well with the IR bands of pure TSC, except wavenumber shift in certain bands\(^{[13]}\), \(^{[14]}\). In the spectrum of pure TSC, we observe band at 1582 cm\(^{-1}\) which can be assigned to the asymmetric and symmetric stretching vibration respectively, of COO\(^{-}\) group. The large downshift of the former band to 1554 cm\(^{-1}\) in the spectra of CdSe-TSC has been appeared. the band at 3446 cm\(^{-1}\) is can be assigned to OH stretching of sodium citrate in the TSC spectra is downshift to 3345 cm\(^{-1}\) in the CdSe-TSC spectra.

Figure 3. FTIR spectra of trisodium citrate and CdSe capped with trisodium citrate
Interdigitated electrodes (IDE) assembled from two individually addressable interdigitated comb-like electrode structures have frequently been used to study the electrical properties of CdSe NPs.

Figure 4 shows electrode that contains of interdigitated Aluminium lines on an glass substrate. It can be achieved using minterdigitated electrodes to measure the surface conductivity of the samples from the following relationship [15].

\[ \sigma_s = \frac{I}{V} \left[ \frac{L}{Wt\ell} \right] \]  

(1)

where, \( t \) is thickness of polymer, \( W \) is the distance fingers (10mm), \( \ell \) is number of fingers is to be (10), and \( L \) is the space between electrodes (100\( \mu \)m).

So that:

\[ \sigma_s = (I/V)\times10^{-3}(\text{S. m}^{-1}) \]

(2)

**Figure 4.** shows electrode that contains of interdigitated Aluminium lines on an glass substrate.

To study the electrical performance and the mechanisms of conduction in CdSe NPs., current-voltage (I–V) characteristics in dark was performed by two-probe method in voltage range (1-40) V for CdSe capped with TSC nanoparticles. I–V behavior of CdSe shown in Figure 5.
DC electrical conductivity is a very important property of semiconducting materials for seeking their applications in photosensitive/photovoltaic devices [16]. The electrical conductivity (DC) of CdSe NPs in dark was performed using two-probe method in the temperature range 293–373 K. DC conductivity at room temperature was equal to $6.3 \times 10^{-7}$.

The temperature dependences of electrical conductivities for the as-prepared NPs are shown in figure 6. All display a semimetallic conductivity and thermal response, the conductivity as a function of temperature can be well expressed by the relation [17]

$$\sigma = \sigma_0 \exp \left( -\frac{\Delta E_a}{kT} \right)$$

(3)
where ΔE_a is activation energy, k the Boltzmann’s constant, T temperature and σ_o is pre-exponential factor. Arrhenius plots of conductivity of CdSe NPs. are shown in figure 7. The exponential increase in DC conductivity with temperature. The value of the activation energy (E_a) is estimated with the help of the slope of ln σ versus 1000/T plot. The graph shows straight lines, which indicate that the conduction in the synthesized samples is through an activated process with activation energy equal 0.3427 ev.

![Image of Arrhenius plot]

**Figure 7.** Variation of Ln σ verses 1000/T (K⁻¹)

4. Conclusions
CdSe in the presence of TSC as a capping agent was synthesized by chemical method. Charge transport properties like I-V and electrical conductivity as a function of temperature have been thoroughly investigated. FESEM images demonstrated to be of spherical shape morphology and nearly well distributed with particle size of about 30 nm. The EDX results showed that the percentage of Cd to Se is 2:1. TSC capping CdSe was confirmed by FTIR a spectroscopy.

5. References

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