International Journal of Chemistry Studies
www.chemistryjournal.in
ISSN: 2581-348X
Received: 18-04-2026, Accepted: 19-05-2026, Published: 03-06-2026
Volume 10, Issue 2, 2026, Page No. 92-95

A review of synthetic application of CdSe nanomaterials

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DOI: https://doi.org/10.66856/chemistry.2026.10.2.10036

Abstract
Semiconducting nanomaterial belongs to group of II-VI organometallic compounds have attracted wider interest of researchers and scientists because of their various potential applications. CdSe nanomaterial is important material of this class group which provides broad range absorption of visible spectra. Size dependent optical and electronic properties of CdSe nanomaterial offers multiple utility of nanostructures in the field of Solar cells, light emitting diode, Catalysis, Biomedical and lasers. Several approaches have developed recently for controlling shape, size and phase of these materials. In this paper, we have reviewed physical and chemical route for synthesis of CdSe nanomaterial and various technological applications in length.

Keywords: Nanomaterial, Optical Properties, Solar Cell, Biomedical, Laser etc

Introduction

Nanometer-sized semiconductor crystallites exhibit properties different from those of the bulk and hold considerable promise in numerous applications in electronics and photonics. The uniqueness of these particles lies in their size-dependent electronic and optical properties arising from the quantum confinement and the large number of unsaturated surface atoms [1].

Semiconducting (II-VI) metal chalcogenide nanomaterials are a group of materials that shows band gap energies straddling from the visible (CdS, CdSe, CdTe) to the ultraviolet (ZnS, ZnSe) region. mostly, cadmium based chalcogenide nanomaterial CdE (E=Se/Te) and their core shell formulations are received wide attention by scientist because of moderately easy synthesis, ability to build high feature nanomaterial in terms of size, shape, photochemical stability and potential to tune the emission and absorption all over the visible region. These nanocrystals are observe as a competent material for biological imaging compared to predictable fluorophores (e.g. organic dyes) and several advantage over fluorescent labels, they exhibit a narrow, tunable, symmetric emission spectrum. CdSe is one more important II– VI semiconducting nanomaterial with spanning bandgap (1·7 eV), size-dependent electronic and optical properties [2]. The world's current circumstances exemplify that nanosized materials (1–100 nm) are relatively demandable in various applications, including photovoltaic solar cells, optoelectronic, biomedical, food and agriculture, textile, and industry. Due to the considerably large surface-to-volume ratio, a catalyst assists a better catalytic activity; therefore, the size-controlled synthesis of nanoparticles is fabricated as a catalyst. Additionally, the enhanced surface-to-volume ratio increases the surface state, which substitutes the activity of electrons and holes [3-4].

Synthesis of CdSe nanomaterial

Semiconducting nanomaterial are produced by two main methods top down and bottom up methods, presented in fig 1, Top down methods includes i.e. Wet chemical etching, Reactive-ion etching, beam lithography, laser ablation, arc discharge and chemical oxidation in this methods bulk material is split down in to lesser participles via mechanical forces. In the bottom up methods the material is originally combine with the help of molecular precursors, which are mainly in the wet-chemical mechanism through precipitation and vapor-phase methods [4-5].

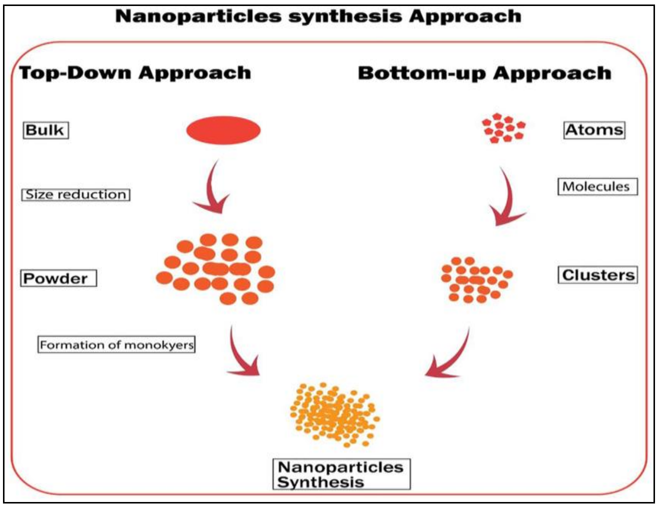

Fig 1: Top Down and Bottom up Scheme of Nanomaterial synthesis [Adapted from Manzar Abbas *et al*., 2022]

Thermal decomposition of colloidal precursors [6-8], sonochemical [9-11], solvothermal/ hydrothermal process [12-13], ionic liquid aid synthesis [14], pulse plasma assisted route [15], microwave assisted route [16-17], solid state reaction [18], spray pyrolysis [19], mechano-chemical synthesis [20], fabrication from elemental powders [21]. Homogeneously dispersed and stabilized nanoparticles are successfully accomplished by means of capping agents and surfactants [22-24]. Semiconductor Cadmium selenide (CdSe) is a type of nanomaterial through forbidden zone of 1.7 eV and its

Valence electrons can be simply evoked to conduction band after the incident light wavelength of fewer than or equivalent to 730 nm [25]. In addition, the rapid fabrication of an electron-hole couple by photo-excitation and the enormously negative reduction potentials of excited electrons make CdSe good photo catalyst [26-27]. On the other hand researchers have faced some complexity through the solvo-thermal decomposition of Metal selenium complex to prepare high grade metal selenide nanoparticles at higher temperature. Though this difficulty can be conquer by function of low weight stabilizer similar to TOPO to synthesize metal selenide nanoparticles [28-29]. Ma *et al* [30]. presented suitable detained precipitation method to organize poly vinyl alcohol (PVA) capped CdSe nanoparticles all through one-step solution progress method at room temperature and nearby pressure. Rapid mixing of moreover aqueous sodium selenide or else seleno urea with cadmium chloride in the presence of aminodextran as stabilizer and capping agent at room temperature produces water dispersible CdSe nanoparticles with sufficient luminescence [31]. Thermolysis of the novel single source precursors, M $[E(Ox)]_2$ [E = S [1], Se [2]; M = Cd; Ox = 2-(4,4- dimethyl-2-oxazolinyl) benzene] in tri-n-octylphosphine oxide (TOPO) at 280°C produce Cadmium sulphide and selenide nanoparticles [32]. The synthesis of CdSe QDs has been matured over the years, and currently the focus is on synthesis routes that use low temperatures, better yield and non-toxic precursors at the same time gives better control to size and shape so as to tune the size-dependent electronic and optical properties. Use of single source molecular precursor provides a general route for the manufacture of high quality CdSe Nanoparticles at moderately lower temperature through a solvothermal route. Our synthesis methods use low cost and non-toxic materials and another striking feature is; it keeps away from the use of inert atmosphere. The novel single source molecular precursor Cd (ii) complex of bis-(aminoethyl) selenide, quinoline is used as a co-coordinating solvent [33].

In this review, we have mainly presented optical, electronic and biomedical application of CdSe nanoparticles, critically analyzed CdSe nanoparticles in the field of Solar cells, Light-emitting diodes (LEDs), Photodetectors and lasers Biomedical and sensing, Targeted drug delivery, Antimicrobial activity etc.

Applications of Cdse nanomaterials

Numerous applications of Cadmium selenide (CdSe) nanoparictils are determined by amazing optical and electronic advancement. Structural properties of nanoparticles plays key role in their selective feature. This includes long lasting light emitting diodes, elevated photoluminiscent properties results Bioimaging. The first absorption characteristic of the CdSe core is extremely typical and contracted. CdSe core QDs indicate that convention size allotment and strong excitation transition offers Key applications light emitting diode (LED), Solar cells, Sensors, Lasers, bioimaging and biomedical identification and catalysts [34]. They are also used in industrial products like rubber and cosmetics and for specific applications like developing latent fingerprints, Optoelectronics and energy. The key features of CdSe nanoparticles are summarized as:

1. **Solar cells:** CdSe dependent quantum dots in the range of 1-6 nm especially use their emission properties and shows blue, green, yellow, red emission characteristics whose size in the range of 2 to 5 nm respectively. The broad band gap of CdSe nanoparticles makes suitable material for quantum dot sensitized solar cells [35-36]. CdSe nanoparticles can be filled into fibers to produce materials that capably absorb sunlight for solar thermal applications [27].

2. **Light-emitting diodes (LEDs):** The tough and tunable photoluminescence properties of CdSe quantum dots makes them important substance for LEDs and displays. Good quality chemical solution of CdSe QDs is largely used as a thin film. The optical dimensions of CdSe QDs are calculated via UV–vis spectrophotometer in the series (450–650) nm. At present a dual semiconductor array is considerably important since the high potential efficiency of these materials as photo detectors, heterojunction diodes, bioimaging, and solar cell semiconductors devices [37].

3. **Photodetectors and lasers:** CdSe nanoparticles are engaged in photodetectors and can be utilize in laser applications [34].

4. **Biomedical and sensing:** Nowadays, various feasible techniques make CdSe QDs attractive in numerous biomedical applications. The variety of excitation and emission properties via the quantum size effect is noticeably helpful in biomedical applications. CdSe QDs, due to their quantum size result, surface outcome, and macroscopic quantum tunneling outcome, demonstrate exclusive properties like visible optical and electrical properties and biocompatibility. Thus, CdSe QDs display vast possibility in the field of biological medicine [38.]

5. **Bioimaging:** Photoluminescence properties of CdSe quantum dots are used for biological imaging and tissue staining, which can be refrain to image particular tissues or structures, including injured tissue [39].

6. **Targeted drug delivery and diagnosis:** The optical properties CdSe QDs make them efficient material for targeted drug delivery systems. Biomedical function of CdSe Qds includes *in vitro* imaging like cellular imaging, biomolecular tracking, tissue staining, binding assays, and *in vivo* imaging like vascular imaging, *in vivo* tracking, tumor imaging, also as MRI divergent agent, and some other precise biomedical function consist of photodynamic therapy, targeted drug delivery, toxin detection, pathogen, agnostic and gene delivery [39]. CdSe QDs Applications include disease diagnosis and use as biological sensors [40].

7. **Antimicrobial activity:** In recent years, Researcher has explore the exercise of CdSe for its antimicrobial properties. They had an extraordinary attention about synthesizing CdSe QDs because of their biological, biomedical and pharmaceutical applications and antimicrobial properties. The Cadmium ion exhibits a wide spectrum of insensitive action against various microbes like viruses, fungi, and bacteria. Recently the polymer blended antimicrobial attainment of prepared CdSe QDs, doped using a variable concentration, is being tested [41].

8. **Other applications:** CdSe nanomaterials are used as catalysts. Cadmium selenide (CdSe) nanomaterials including quantum dots, nanorods, and nanoplatelets are powerful n-type semiconductors extensively employ in photocatalysis, solar-to-chemical energy conversion and environmental remediation [42]. CdSe nanoparticles are used in production of industrial products such as additives in products like rubber and cosmetics [43]. CdSe nanoparticles are used in a method for developing latent fingerprints on surfaces [44].

Conclusion

CdSe nanoparticles are generally inorganic materials synthesized from inorganic metal complexes, which are coated with organic materials, which makes them biocompatible and biologically active. Various Synthetic approaches used for the preparation of these technologically significant nanomaterials are reviewed with a view to get present status of controlling their sizes and shapes. Further, considering the environmental concerns, new single molecular precursors developed for the preparation of chalcogenide nanoparticles are presented and their important properties are critically analyzed also highlights the admirable features of CdSe nanoparticles in the field of Solar cells, Light-emitting diodes (LEDs), Photodetectors and lasers Biomedical and sensing, Targeted drug delivery, Antimicrobial activity etc. However, there is not only compensation of CdSe QDs but also a few confront faced by their achievement, which comprise cellular toxicity due to the production of reactive oxygen species and cadmium release (for cadmium containing QDs). The main toxicological danger of QDs in the living body is the exposé of inorganic core due to the split of the organic. The exclusive properties of these materials, especially the potential for tailoring energy band gap and tuned luminescence, may lead to their probable function in several future technologies.

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