Original Research Article

Synthesis and Characterization of ZnS nanoparticles using Co-precipitation method

ABSTRACT

ZnS nanoparticles were prepared from homogeneous chemical co-precipitation reaction by using zinc acetate, sodium sulfide [Na_2S] and Poly Vinyl Polypyrrolidone [PVP]. The basic, morphological, and optical properties of the synthesized nanoparticles were characterized using Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), Energy Dispersive X-ray Analysis (EDX) and Ultraviolet-Visible (UV-Vis) absorption. The structural and optical characterization of the samples observed by SEM, FTIR, EDX and UV-Vis spectrometer showed that ZnS nanoparticles were formed.

Keywords: Nanoparticle, Precipitation, Zinc Sulfide, Characterization Techniques

1. INTRODUCTION

Nanoparticles or quantum dabs are characterized as little particles with 1-100 nm based on their As the breadths of the particles approach their Bohr width, the optical properties start to change and quantum repression impact starts to play a considerably more significant job. It acquires extraordinary distinction in physical and electronic properties of the nanometer scale particles in contrast to mass of the materials. Among the group of semiconductors, II-VI bunch semiconductor mixes have enormous innovative significance in different applied fields of science and innovation. For example, ZnS [1-2], CdS [3], ZnO [4], CdTe [5] and so forth., are significant in view of their fantastic electronic and optical properties for optoelectronic applications. Among those ZnS is a significant part in II-VI group semiconductors having a bigger estimation of band hole vitality [6]. It has two structures: a cubic structure and a hexagonal structure [7-8]. Progress from mass to nanoparticles lead to the presentation of quantum mechanical properties and an expanded strength of surface ions which builds the substance reactivity of a material. Prominent models incorporate the tunable band hole [9] and synergist behavior [10] of nanoparticles. For nano precious stones whose arrangements are based on synthetic techniques, a topping operator that adsorbs to the nano gems surface, most of the part is added both to control the size of nano gems and to forestall agglomeration of combined nano gems. Polymers are considered as acceptable host materials since they typically display long haul dependability and have adaptable reprocess capacity. The little size and high optical movement of ZnS nanoparticles make them fascinating for optoelectronic applications working in the bright locale [11]. In the past decade, semiconductor miniaturized scale/nanoparticles have been combined through different ways including aqueous procedure, small scale emulsion technique, sol-gel strategy, substance coprecipitation strategy , sonochemical strategy , microwave light and solvo thermal strategy [12] and so on. In any case, these techniques ordinarily comprise of at least two stages and thorough conditions, for example, high weight or high temperature, as a rule are required [13]. Creation of inorganic nanoparticles in strong polymer networks has provided impressive intrigue that has enabled the mix of these inorganic particles and polymers to be used in a straightforward course for the readiness of steady and processed

materials that have promising properties of the two segments [14]. ZnS nanoparticles could be utilized as acceptable photograph impetuses because of quick age of the electron-gap matches by photograph excitation and exceptionally negative decrease possibilities of energized electrons; as conduction band position of ZnS in watery arrangement is higher than that of different semiconductors, for example, TiO_2 and ZnO. Since, a bigger proportion of surface to volume of an impetus would encourage a superior synergist movement [15]; the size controlled amalgamation of ZnS nanostructures to deliver a bigger proportion of surface to volume is critical. The improved surface to volume proportion causes increment of surface states, which change the action of electrons and gaps, influencing the substance response elements. The size quantization builds the band hole of photograph impetuses to improve the redox capability of conduction band electrons and valence band gaps [16]. In the present work, ZnS nanoparticles are set up by coprecipitation system and zinc acetate, Sodium sulfide and PVP are utilized as topping and balancing out specialists, which change surface of nanoparticles and forestalls the development of the molecule to bigger size. The impact of topping operator on optical assimilation spectra has been explored. SEM, FTIR, UV spectra and EDX reads are made for these examples. To investigate conceivable use of the ZnS nanoparticles, the synergist debasement of XO is completed under the presentation of daylight.

2. MATERIALS AND METHOD

2.1 Selection of Materials

Zinc acetate; Zinc is a normally occurring mineral. It is significant for development and for the advancement and strength of body tissues. Zinc acetate is used to treat and to forestall zinc insufficiency. Zinc acetate may likewise be used for various purposes not included in this study [17]. Sodium sulfide; Sodium sulfide is the synthetic compound having a formula Na_2S, or normally occurs in its hydrate form; $Na_2S.9H_2O$. Both are water-dissolvable salts that give unequivocally basic medium. In the presence of soggy air, Na_2S and its hydrates discharge hydrogen sulfide, which has a smell of spoiled eggs [18]. Polyvinyl Polypyrrolidone; Polyvinylpolypyrrolidone is an exceptionally cross-connected adjustment of polyvinylpyrrolidone. The cross-connected type of PVP is utilized as a disintegrant in pharmaceutical tablets [19]

2.2 Synthesis of Nanoparticles

The different methods for the synthesis of nanoparticles are presented in Fig. 1. The techniques include: Co-precipitation, hydrothermal synthesis, inert gas condensation, sputtering, microemulsion, microwave, laser ablation, sol-gel, ultrasound, spark discharge, template techniques. Nanostructure is a structure with at least ID or 2D in the range of 1–100 nm. By these techniques, nanoparticles and particles of Zn_2S dry in the form of liquid dispersion after synthesis. The word ‘synthesis’ refers to creation of nano size particles that may be synthesized by ‘bottom-up’ methods. While considering nanoparticle application that depends upon parameters like size, composition of chemical and shape of the particles.

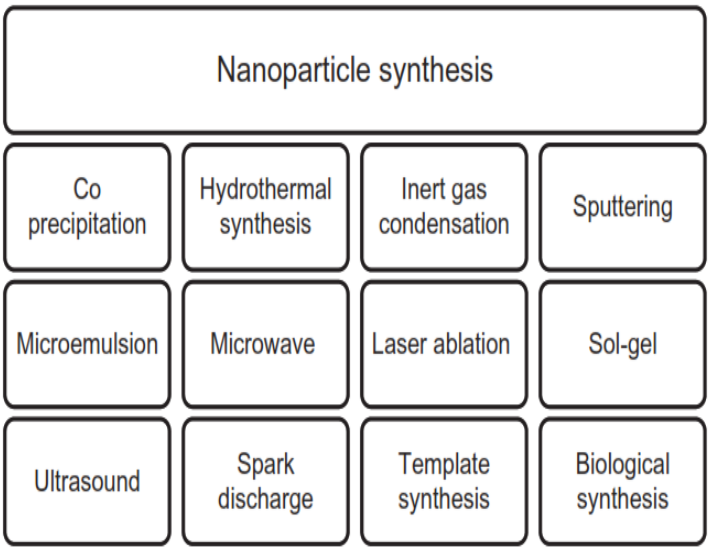

Fig. 1 Various techniques of Nanoparticle synthesis

2.3 Co-precipitation

Co-precipitation is a traditional method that involves: nucleation, development, coarsening, as well as agglomeration forms. Co-precipitation responses display the accompanying attributes: The items are commonly insoluble species shaped under states of high supersaturation; Nucleation is a key and allows an enormous number of little particles to be framed; Secondary procedures, for example, Ostwald maturing and conglomeration, significantly influences the size, morphology, and properties of the items; The supersaturation conditions are important to actuate precipitation and are typically the aftereffect of a synthetic response.

$$XAy^{+}_{(aq)} + yBx^{-}_{(aq)} \rightarrow AxBy_{(s)}$$

Points of interest of co-precipitation technique include: Simple and fast arrangement; Easy control of molecule size and creation; different prospects to adjust the molecule surface state and generally speaking homogeneity; Low temperature; Energy effective; Does not include utilization of natural dissolvable. Disservices incorporate: Not material to uncharged species; Trace pollutions may likewise get accelerated with the item; Time devouring; Batch-to-bunch reproducibility issues; this technique doesn't function admirably if the reactants have altogether different precipitation rates. (The gramma in this section makes it difficult to follow- Revise)

2.4 Preparation of ZnS Nanoparticles

Fig 2 shows the arrangement of ZnS nanoparticles preparation procedures. 50 ml of zinc acetic acid derivation and 1% of PVP (Poly Vinyl Polypyrrolidone) were combined and mixed for 30 minutes on an attractive stirrer to get a homogeneous arrangement. This was trailed by drop astute expansion of proper measure of 0.1 M Na_2S under energetic mixing for 60 minutes. A white shading accelerate was isolated by centrifugation and washed a few times with twofold refined?? water. The precipitate was dried at a temperature of 80°c for time duration of 4 hours to get powder test.

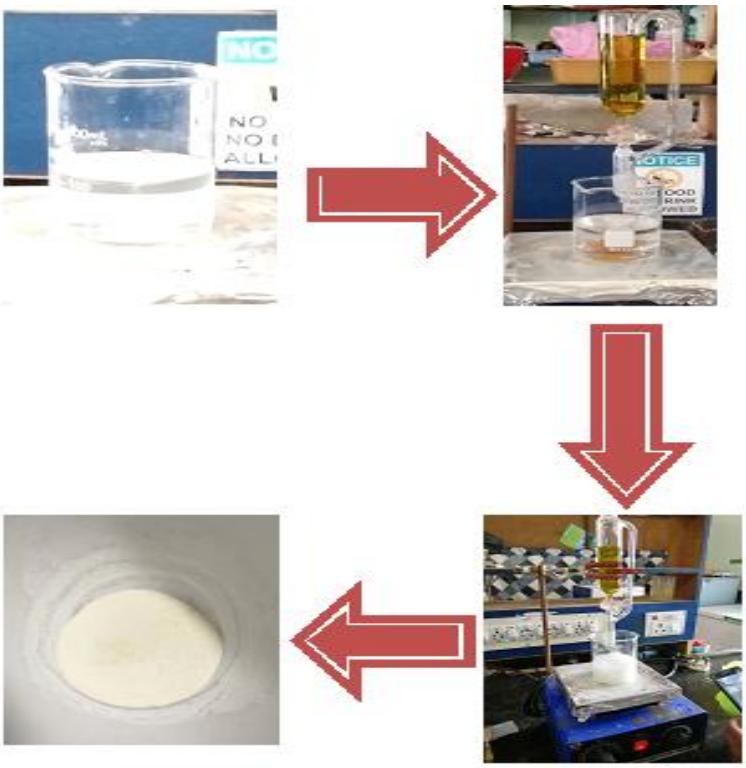

Fig 2 Preparation of ZnS nanoparticles

2.5 Characterization Techniques

2.5.1 Scanning Electron Microscope

Structure and surface morphology was studied by scanning electron microscopy. SEM images of the dried sample were taken using Jeol (JSM-6100) scanning microscope operating at 25 kV.

2.5.2 Fourier Transform Infrared Spectroscopy

The FT-IR spectra were recorded using BRUKER spectrometer in the range of 400-4000 cm-1 at room temperature in KBr pellets to confirm the formation of ZnS nanoparticles.

2.5.3 Dispersive X-ray Analysis (EDX)

The optical absorption spectra of ZnS nanoparticles were recorded using Perkin – Elmer LAMBDA 950. For this, the ZnS nanoparticles were well dispersed in ethanol.

2.5.4 UV-Visible Spectroscopy

UV-vis spectra of the nano dispersions were recorded in Jasco-530 spectrophotometer with matched pair of quartz cell of 1 cm path length.

3. RESULTS AND DISCUSSION

3.1 SEM Analysis

The morphology of the prepared samples was analyzed through SEM. Fig. 3 and Fig. 4 shows the SEM image of pure ZnS nanoparticles. From the SEM image it is clear that the particles have spherical shape and agglomerated. Fig. 3 shows the agglomerate spherical structure. Fig. 4 shows the porous particles.

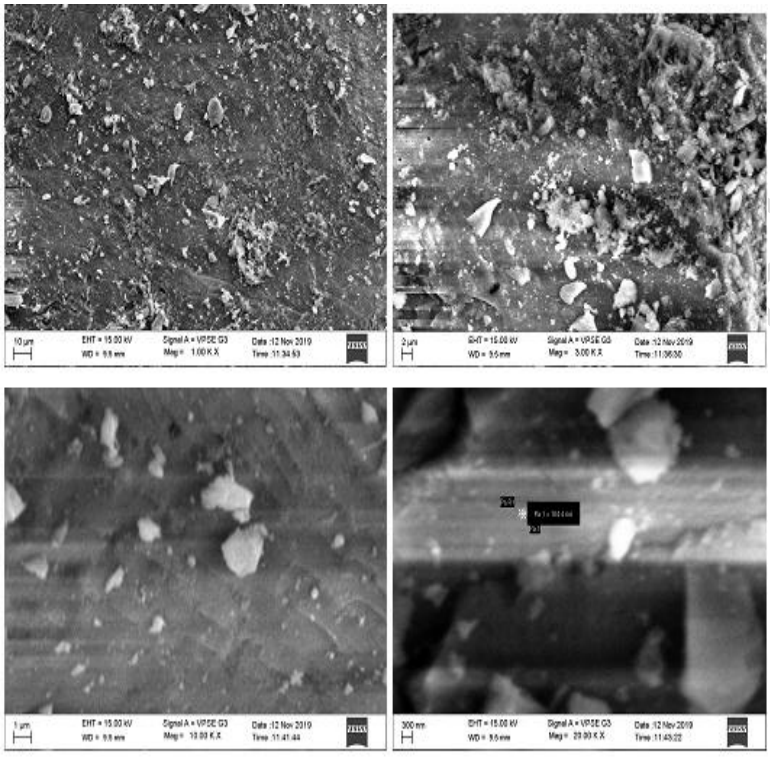

Fig 3 SEM images of ZnS nanopaticles - spherical structure

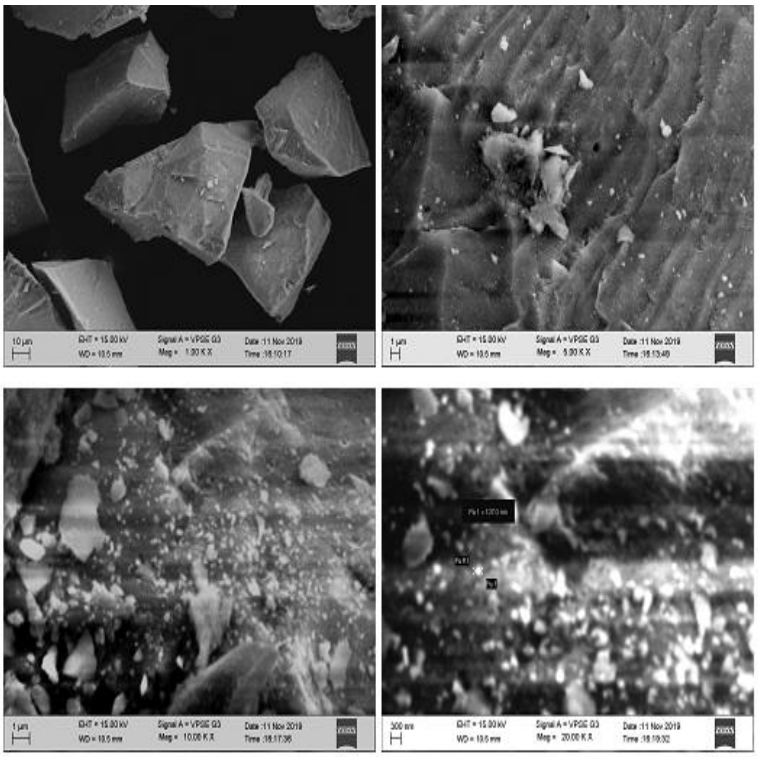

Fig. 4 SEM images of ZnS nanopaticles – porous particle

3.2 FT-IR Analysis

The FT-IR spectra were recorded using BRUKER spectrometer in the range of 400-4000 cm^{-1} at room temperature to confirm the formation of ZnS nanoparticles. Fig. 5 shows the FT-IR spectra of ZnS nanoparticles respectively.

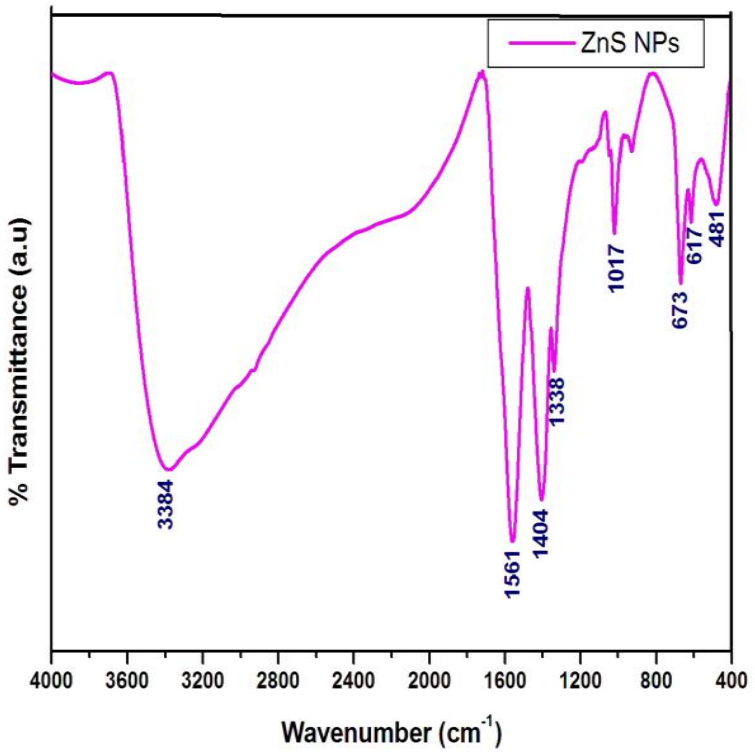

Fig. 5 FTIR Spectra of ZnS nanoparticles

The peaks observed at 3384 cm^{-1} are corresponding to the O-H stretching vibrations of the adsorbed water molecules at the surface of ZnS nano-particles respectively [20]. The peaks observed at 1561 cm^{-1} are corresponding to the C-C stretching vibrations [21]. The band observed at 1404 cm-1is attributed to the C-H stretching of aromatic amide. The peak observed at 1017 cm^{-1} is due to stretching vibrations of C-O-C [22]. The peaks observed at 673 cm-1 and 617 cm^{-1} are corresponding to the O-H stretching mode. The Zn-S stretching vibration is observed at 481 cm^{-1}. It shows the formation of ZnS nanoparticles.

3.3 Energy Dispersive X-ray Analysis (EDX)

Fig. 6. Shows the Energy Dispersive X-ray Analysis spectra of ZnS nanoparticles. This shows the nearness of zinc and sulfide in better expectations. Accordingly the outcomes affirm the nearness of zinc in significant level when contrasted with sulfide material. This examination demonstrates the optical assimilation pinnacles of ZnS nanoparticles and these retention tops were because of the surface plasmon resonance of zinc sulfide nanoparticles. Table. 1 shows the percentage of atomic and weight ratio of ZnS Nanoparticles

Table 1. Percentage of atomic and weight ratio of ZnS Nanoparticles

Element	Weight %	Atomic %
Zn K	63	54.49
S K	37	45.51
Total	100	100

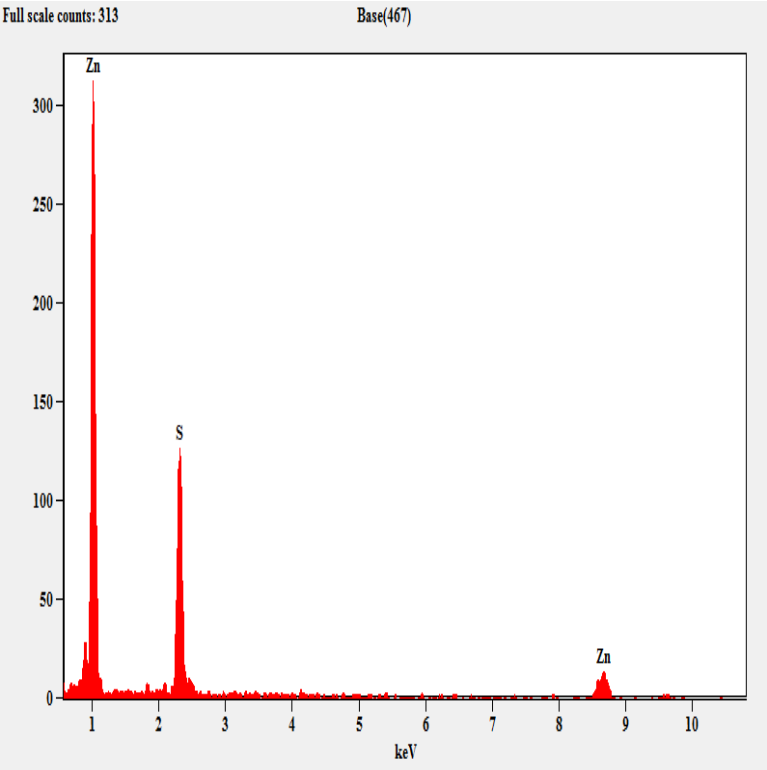

Fig. 6 EDX Spectrum of ZnS nanoparticles

3.4 UV – Visible Spectroscopy Analysis

The optical absorption spectra of ZnS nanoparticles were recorded using Perkin – Elmer LAMBDA 950. For this, the ZnS nanoparticles were well dispersed in ethanol. Fig. 7 shows the UV-Visible absorption spectra of ZnS nanoparticles respectively. The direct band gap of bulk ZnS is 3.68 eV at room temperature [23].

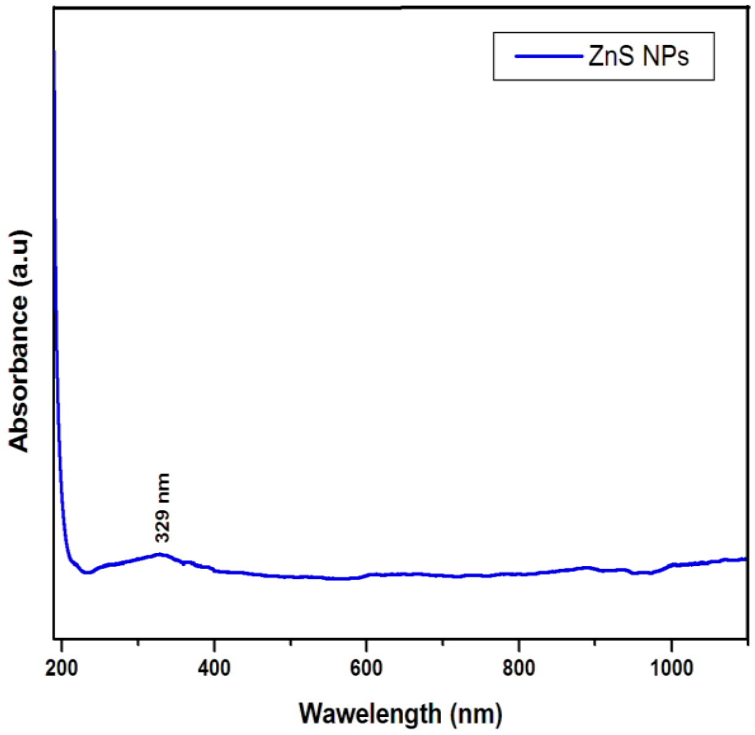

Fig. 7 UV-Vis absorption Spectra of ZnS nanoparticles

4. CONCLUSIONS

The structural and optical characterization of the samples observed by SEM, FTIR, UV-Vis spectrometer and EDX showed the formation of ZnS nanoparticles. From the SEM image it is clear that the ZnS nanoparticles particles has spherical shape and agglomerated. FTIR spectra showed the possible stretching and bending modes of the ZnS nanoparticles. UV-Vis spectrometer showed the absorbance of ZnS nanoparticles. The EDX examination revealed the optical assimilation pinnacles of ZnS nanoparticles and the retention tops which were due to the surface plasmon resonance of zinc sulfide nanoparticles. No other impurity peaks were observed.

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