A Review of Fabrication and Characterization of Zinc Sulfide Nanoparticlesand Nanocomposites Prepared via a Simple Chemical Precipitation Method

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Abstract:
In this research zinc sulfide (ZnS) nanoparticles and nanocomposites powders were prepared by chemical precipitation method using zinc acetate and various sulfur sources. The ZnS nanoparticles were characterized by X-ray diffraction, scanning electron microscopy, ultraviolet-visible and fourier transform infra-red. The structure of nanoparticles was studied using X-ray diffraction pattern. The crystallite size of ZnS nanoparticles was calculated by Debye–Scherrer formula. Morphology of nano-crystals was observed and investigated using the scanning electron microscopy. The grain size of zinc sulfide nanoparticles were in suitable agreement with the crystalline size calculated by X-ray diffraction results. The optical properties of particles were studied with ultraviolet-visible absorption spectrum.

Keywords: *Nanoparticle Precipitation Zinc Sulfide*

1. Introduction

Among the family of semiconductors, II-VI group semiconductor compounds have immense technological importance in various applied field of science and technology. For instance ZnS, CdS, ZnO, CdTe etc., are important because of their excellent electronic and optical properties for optoelectronic applications. Zinc sulfide is a very important semiconductor with a direct wide band gap of 3.37 eV and a large exciton binding energy of 60 meV at room temperature. So far, extensive efforts have been made on the synthesis of low dimensional ZnS nanostructures, including nanoparticles, nanowires, nanobelts, nanocables, and nanotubes. For ZnS, the sphalerite (cubic zinc blende) structure is a stable phase at low temperature, whereas the wurtzite (hexagonal) structure is a high-temperature stable phase. Nanoparticles (NPs) which are smaller than that of the bulk Bohr excitonic radius exhibit blue shift in the optical transition and yields high photoluminescence (PL) property. In this regard ZnS is a technologically important II-VI luminescent semiconductor and shows band gap energies of 3.68 eV for cubic and 3.9 eV for wurtzite phase. In this work, the precipitation method was used to prepare ZnS/ZnO nanoparticles. Then the crystallinity, size, morphology, and optical properties of ZnS nano particles were investigated.

2. Materials and methods

For the synthesis of zinc sulfide nanoparticles, the following procedure was used. The chemical precursors used in reaction zinc acetate dehydrate ($Zn(CH3COO)2·2H2O$), thio urea, sodium sulfate, thioglycolic acid and distilled water (all materials from Merck Company were used without further purification). 0.001 mol of zinc acetate and 0.001 mol of sulfur source were dissolved in 100 ml of deionized water. Structure of nanoparticles was studied using X-ray diffraction with CuKα (λ=1.54 Å) radiation. The shape and size of nanoparticles were investigated by scanning electron microscope images. Analyze for elemental was obtained using EDX. The optical properties of ZnS nanoparticles were analyzed using UV–Vis spectroscopy. The FTIR analysis performed in order to determine the materials existed in ZnS sample. All the chemical materials were used as received without further

purifications. X-ray diffraction (XRD) patterns were recorded by a Philips X-ray diffractometer using Ni-filtered CuKα radiation. Scanning electron microscopy (SEM) images were obtained using a LEO instrument (Model 1455VP). Prior to taking images, the samples were coated by a very thin layer of Pt (BAL-TEC SCD 005 sputter coater) to make the sample surface conducting obtain better contrast and prevent charge accumulation.

3. Results and Discussion

The XRD pattern of ZnS nanoparticles is shown in Fig. 1. XRD analyses were performed to determine the crystalline structure and phase formation of zinc sulphide nanoparticles. The XRD pattern of ZnS/ZnO nanoparticles is shown in Fig. 2. The nanoparticles crystallite size was calculated from X-ray line broadening using Debye–Scherrer equation.

$$D=0.9\lambda/\beta \cos\theta \quad (1)$$

where λ is the X-ray wavelength (CuKα radiation equals to 1.54Å), θ is the Bragg diffraction angle, and β is the FWHM of the XRD peak appearing at the diffraction angle θ. The crystalline size of ZnS nanoparticles calculated about 4 nm by Debye– Scherrer equation. SEM images of ZnS nanoparticles by KOH are shown in Fig. 3. Microscopic images confirm starlike nanostructures were synthesized.

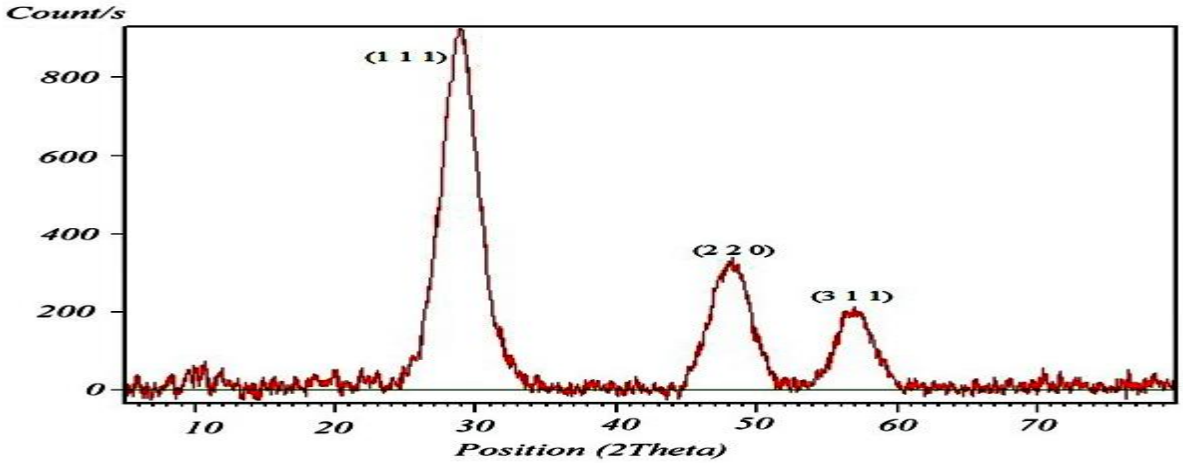


Fig. 1. XRD patterns of ZnS nanoparticles

SEM image of ZnS nanoparticles by NaOH are illustrated in Fig. 4. Images also approve star-like nanostructures with average diameter less than 100 nm were obtained. Fig. 5 show SEM images of ZnS nanoparticles obtained at presence of thioglycolic acid (TGA). Results confirm that agglomeration was observed in images and bigger particles with average diameter around 150 nm were synthesized. SEM image of ZnS nanoparticles synthesized by thio-urea are shown Fig. 6. Outcomes show trigonal nanostructures with mediocre sized less than 100 nm were achieved. Fig. 7 illustrates SEM images of ZnS nanoparticles synthesized by both thio-urea (TU).

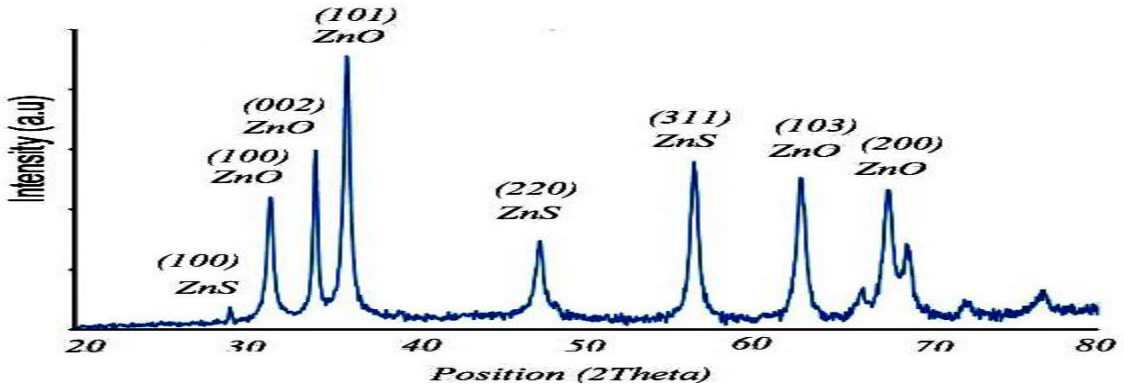


Fig. 2. XRD patterns of ZnS/ZnO nanoparticles

and sodium sulfide. Results approve agglomerated nanoparticles with average diameter less than 100 nm were obtained. It seems by using thioglycolic acid growth stage is preferential compare to nucleation stage. Fig. 1. XRD patterns of Optical absorption spectra of samples using UVVis are indicated in Fig. 8. The absorption spectra indicate the excitonic shoulder peaks of ZnS nanoparticles. Fig. 9 shows the FTIR spectrum of the ZnS nanoparticles. The peak at 405 cm−1 is the characteristic absorption of Zn–S bond.

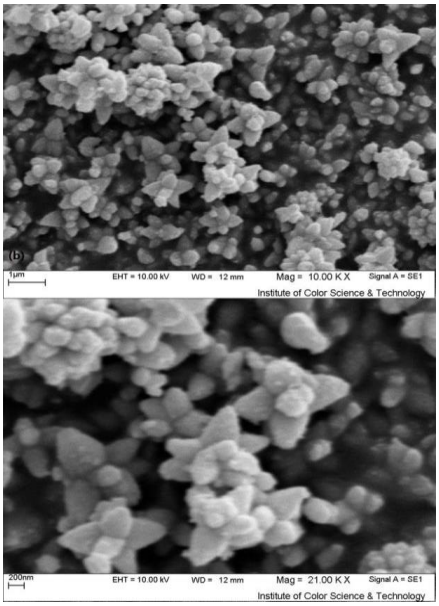


Fig. 3: SEM images of ZnS nanoparticles by KOH

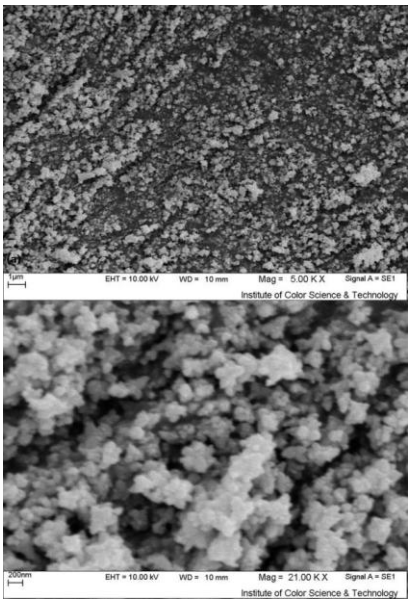


Fig. 4: SEM image of ZnS nanoparticles by NaOH

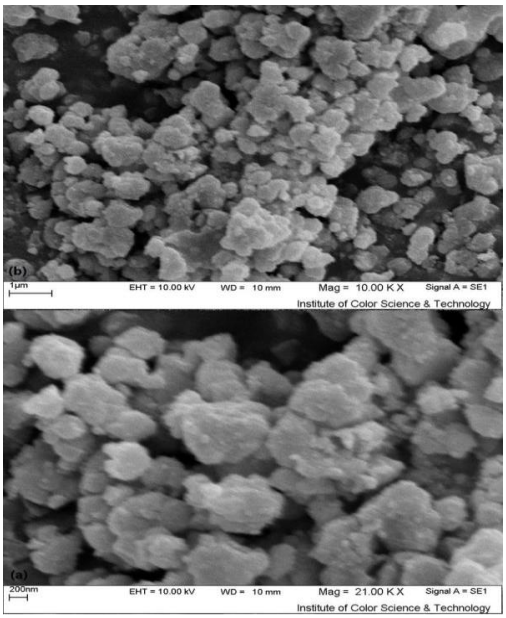


Fig. 5: SEM image of ZnS nanoparticles by TGA

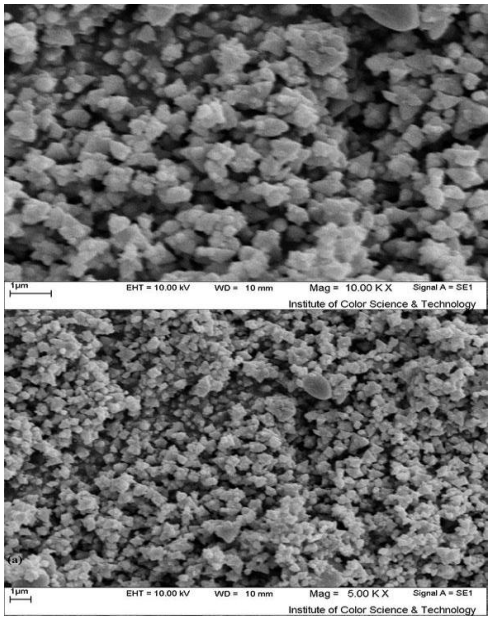


Fig. 6:SEM image of ZnS/ZnO nanoparticles by TU

4. Conclusions

In this research zinc sulfide (ZnS) nanoparticles and nanocomposites powders were prepared by chemical precipitation method using zinc acetate. The ZnS nanoparticles were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), ultraviolet-visible (UV-Vis) and Fourier transform infra-red (FT-IR).

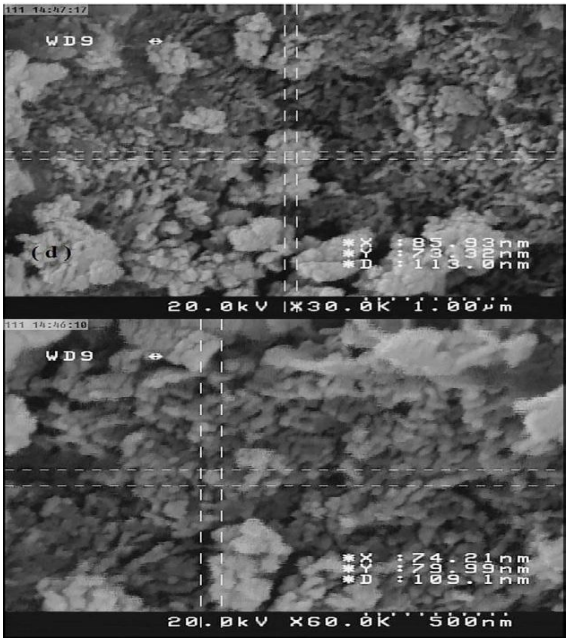
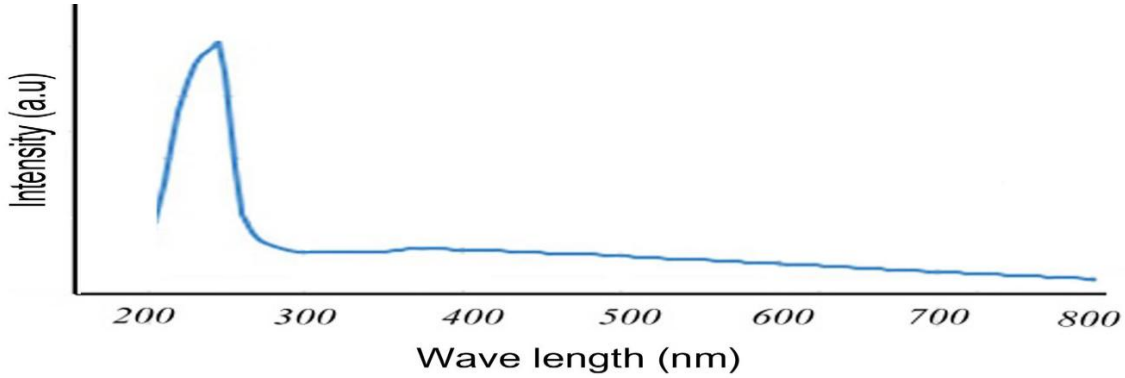


Fig. 7. SEM image of ZnS nanoparticles by thiourea and Na2S

The structure of nanoparticles was studied using XRD pattern. The crystallite size of ZnS nanoparticles was calculated by Debye–Scherrer formula. Morphology of nanocrystals was observed and investigated using the SEM. The grain size of zinc sulfide nanoparticles were in suitable agreement with the crystalline size calculated by XRD results. The optical properties of particles were studied with UV-Vis an FTIR absorption spectrum.



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