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Preparation and Spectral Analysis of Nano sized ZnSe Particles

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Abstract

ZnSe nanoparticles have been successfully prepared by hydrothermal method by the reaction of zinc acetate dihydrate with sodium selenite anhydrous in the presence of hydrazine hydrate as a reducing agent. The produced sample was characterized by different techniques such as X-ray powder diffraction (XRD), High resolution transmission electron microscope (HR-TEM), Field emission scanning electron microscope (FE.SEM). The average crystallite size of the as-prepared ZnSe nanoparticles was estimated to be 9.1 nm. The HR-TEM images revealed that zinc selenide nanoparticles have irregular shapes. While the FE-SEM images showed that the produced ZnSe nanoparticles are agglomerated in spherical shapes.

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1. Introduction

Semiconductor nanoparticles are very important materials due to their tunable electrical and optical properties [1,2]. Their physical properties depend on their crystallite sizes [3]. The preparation and characterization of II-VI semiconductor nanocrystals have attracted much attention recently due to their great potential in optoelectronic applications in the fields of light-emitting diodes (L.EDs), solar cells, sensors, and optical recording materials [4-10]. Zinc selenide (ZnSe) is an important II-VI semiconductor with a low absorptivity at infrared wavelength as well as visible transmission. ZnSe is an important material in shorter wavelength applications. It has wide range of applications in blue laser diodes, optical instruments, high speed optical devices, photovoltaic and laser screens [11-17] due to its wide band gap (2.7 eV), wide transmittance range (0.5-2.2µm), high luminescence efficiency, low absorption coefficient, excellent transparency to infrared radiations and high exciton binding energy (21 meV). Many methods are used for synthesis of ZnSe nanoparticles such as sonochemical method [18], surfactant-assisted chemistry methods [19], reverse micelle synthesis [20], solvothermal method [21], and microwave-irradiation method [22]. The hydrothermal method was successfully method for preparation of many nanostructures [23-27]. In this study ZnSe was prepared by hydrothermal method, and avoiding the use of expensive materials which sodium selenite is used as source of selenium instead of selenium metal which is very expensive and hydrazine hydrate is used as reducing agent instead of sodium borohydride.

2. Experimental

2.1. Materials and reagents

All chemicals used in this work were purchased and used as received without any further purification: zinc acetate ($Zn(CH_3COO)_2.2H_2O$) was purchased from (Sigma-Aldrich company), sodium selenite anhydrous (Na_2SeO_3) was purchased from (Sigma-Aldrich company) and hydrazine hydrate ($N_2H_4.H_2O$) was purchased from (Sigma-Aldrich company).

2.2. Preparation of ZnSe nanoparticles

Zinc selenide (ZnSe) nanoparticles have been successfully prepared by the hydrothermal method in a Teflon-sealed autoclave. In typical synthesis, 2 gm of zinc acetate dihydrate was dissolved in 100 mL of deionized water under strong magnetic stirring; Then 4 g of sodium selenite anhydrous was added. Then 20 mL of hydrazine hydrate was added. The mixture was transferred into a Teflon-lined stainless steel autoclave with a capacity 100 mL and kept at 200 ºC For 24 hours. The obtained yellowish precipitate was collected by centrifugation, washed with deionized water and absolute ethanol several times then dried at 80 ºC overnight.

2.3. Characterization

The crystallinity and phase purity of the as-prepared samples were identified using powder XRD patterns obtained with an X-ray diffractometer (Bruker, model D8 Advance) with monochromated Cu Kα radiation (wavelength=1.54178 Aº) at a scanning rate of 2º min^{-1} and a step size of 0.02º in the 2θ range of 10-80º. The surface morphology of the as-prepared samples was studied using a field emission scanning electron microscope (FE-SEM; JEOL JSM-6390). A high-resolution transmission electron microscope (HR-TEM; JEM-2100) with an accelerating voltage of 200 KV was used to investigate the particle size and the detailed morphology of the products.

3. Results and discussion

3.1. Synthesis of ZnSe nanoparticles

3.1.1. XRD analysis

Zinc selenide (ZnSe) nanoparticles have been successfully prepared by hydrothermal method from reaction of zinc acetate dihydrate with sodium selenite in the presence of hydrazine hydrate as a reducing agent. Fig. 1. depicts the XRD reflections of the as-prepared zinc selenide (ZnSe). All the diffraction peaks can be well assigned to a pure cubic phase of ZnSe which matches with the standard diffraction peaks of zinc selenide, Stilleite, syn, with cell constants: a= 5.6700 ˚A, b= 5.6700 ˚A and c= 5.6700 ˚A (space group F-43m, JCPDS card 01-088-2345). Other diffraction peaks from impurities have not been observed. The calculated average crystallite size, D, of the as-prepared zinc selenide (ZnSe) nanoparticles was estimated to be 9.1 nm using the following Debye-scherrer formula:

$$D=0.9\lambda/\beta\cos\theta_B$$

Where, λ, β and θ_B are the X-ray wavelength, full width of the XRD pattern peaks at half maximum (FWHM), and Bragg diffraction angle, respectively.

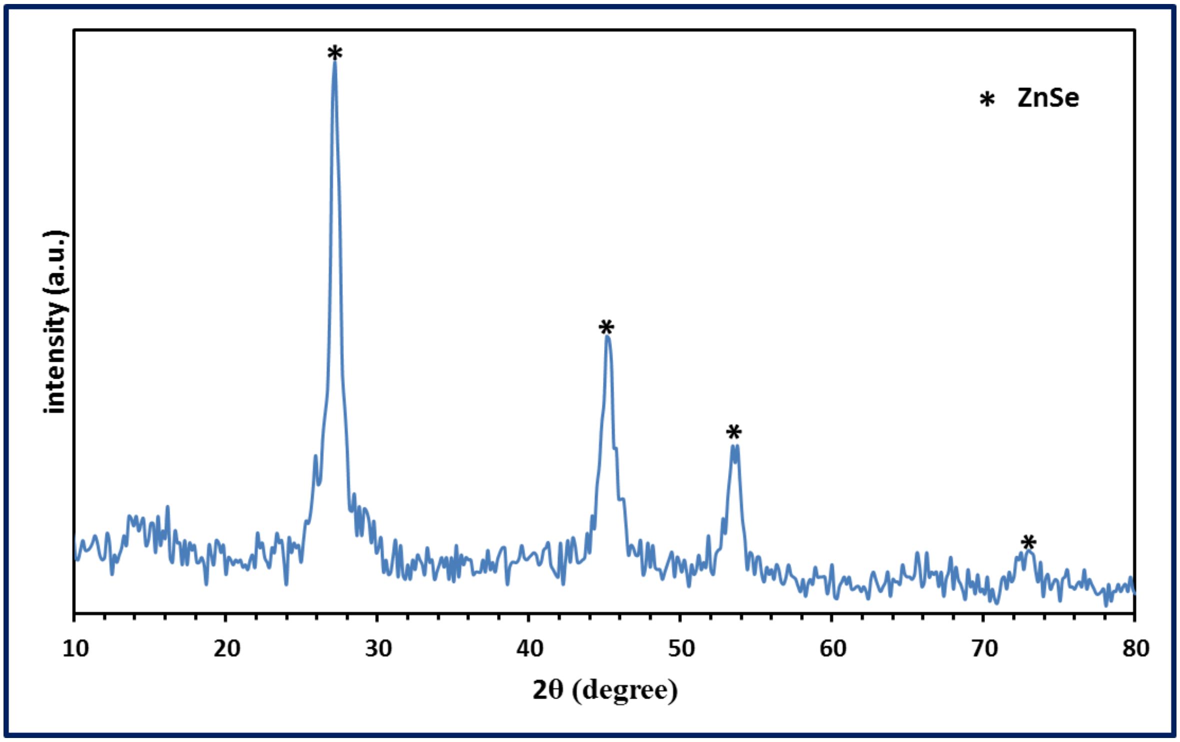

Fig. 1. XRD pattern of the as-prepared ZnSe nanoparticles.

3.1.2. Morphological studies

The surface morphology of the as-prepared ZnSe nanoparticles was studied by field emission scanning electron microscope (FE-SEM). Fig. 2 presents the FE-SEM image of the as-prepared zinc selenide nanoparticles. The FE-SEM image shows that ZnSe nanoparticles are composed of spherical shaped agglomerations with an average diameter of 1 µm. Moreover, the detailed morphology of the as-fabricated zinc selenide nanoparticles was studied using high resolution transmission electron microscope (HR-TEM). Fig. 3. displays the TEM image of the as-prepared product. The TEM image revealed that the as-fabricated zinc selenide nanoparticles consisted of spherical, cubic, hexagonal, and irregular shaped particles. The average particle size was estimated using TEM images, and it was found to be ca. 10 nm which is in good agreement with the results obtained from the XRD technique.

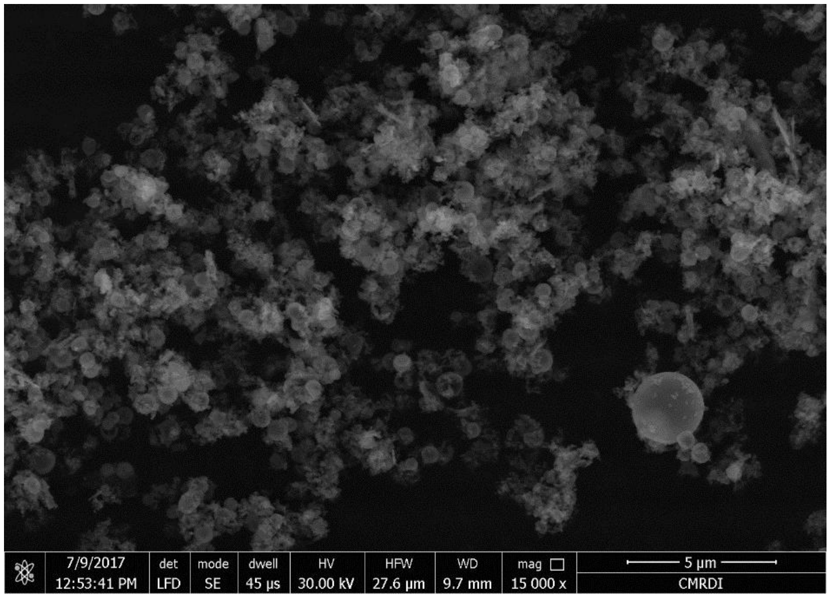

Fig. 2. FE-SEM image of the as-prepared ZnSe nanoparticles.

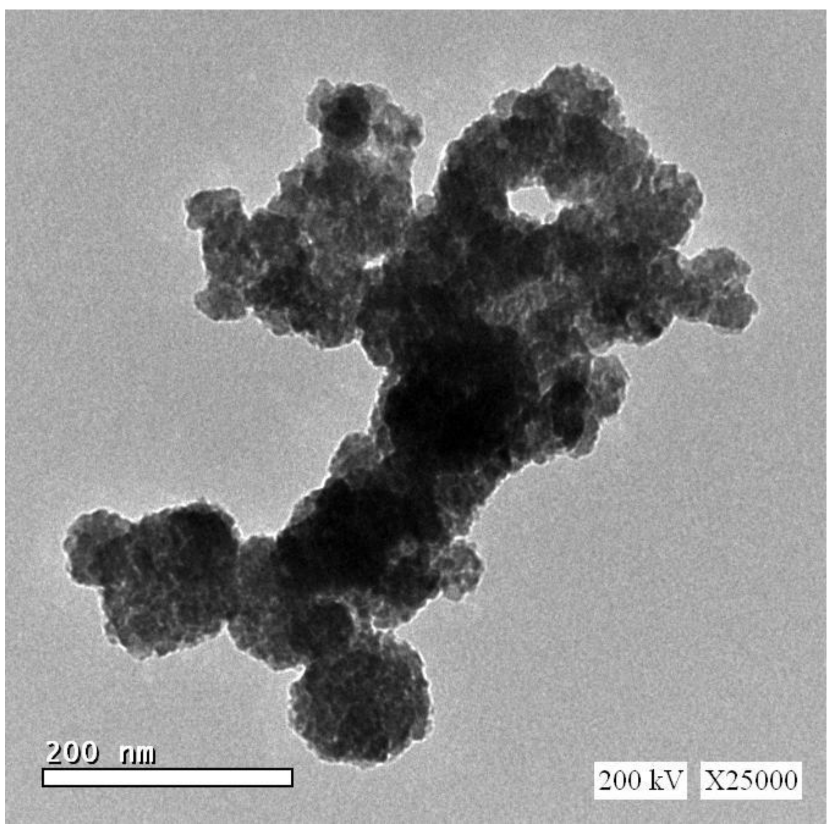

Fig. 3. HR-TEM image of the as-prepared ZnSe nanoparticles.

4. Conclusion

Zinc selenide (ZnSe) nanoparticles were prepared by hydrothermal method from the reaction of zinc acetate dihydrate with sodium selenite anhydrous in the presence of hydrazine hydrate as a reducing agent. The produced products were characterized by using different analytical tools such as X-ray powder diffraction (XRD), High resolution transmission electron microscope (HR-TEM), Field emission scanning electron microscope (FE.SEM). The average crystallite size of the as-prepared ZnSe nanoparticles was found to be 9.1 nm using the XRD technique which as compatible with that calculated using TEM images. The produced ZnSe nanoparticles are agglomerated in spherical shapes as shown by field emission scanning electron microscope images (FE-SEM).

References

[1] G. M. Dalpian and J. R. Chelikowsky, Self-purification in semiconductor nanocrystals, Phys. Rev. Lett., 2006, 96, (226802-1) -(226802-4).

[2] M. A. Malik, N. Revaprasadu and P. O,Brien, Air-Stable Single-Source Precursors for the Synthesis of Chalcogenide Semiconductor Nanoparticles, Chem. Mater., 2001, 13, 913-920.

[3] M. A. Hines and P. Guyot-Sionnest, Bright UV-Blue Luminescent Colloidal ZnSe Nanocrystals, J. Phys. Chem. B, 1998, 102, 3655-3657.

[4] M. A. Hines and P. Guyot-Sionnest, Synthesis and Characterization of Strongly Luminescing ZnS-Capped CdSe Nanocrystals, J. Phys. Chem., 1996, 100, 468-471.

[5] L. Yang, R. Xie, L. Liu, D. Xiao and J. Zhu, Synthesis and Characterization of ZnSe Nanocrystals by W/O Reverse Microemulsion Method: The Effect of Cosurfactant, J. Phys. Chem., 2011, 115, 19507-19512.

[6] L. Yang, J. Zhu and D. Xiao, Microemulsion-mediated hydrothermal synthesis of ZnSe and Fe-doped ZnSe quantum dots with different luminescence characteristics, RSC. Adv.,2012, 2, 8179-8188.

[7] A. Shavel, N. Gaponik and A. Eychmuller, Efficient UV-Blue Photoluminescing Thiol-Stabilized Water-Soluble Alloyed ZnSe(S) Nanocrystals J. Phys. Chem. B, 2004, 108, 5905-5908

[8] N. Pradhan and X. G. Peng, Efficient and Color-Tunable Mn-Doped ZnSe Nanocrystal Emitters: Control of Optical Performance via Greener Synthetic Chemistry, J. Am. Chem. Soc., 2007, 129, 3339-3347

[9] S. M. Emin, N. Sogoshi, S. Nakabayashi, T. Fujihara and C. D. Dushkin, Kinetics of Photochromic Induced Energy Transfer between Manganese-Doped Zinc-Selenide Quantum Dots and Spiropyrans, J. Phys. Chem. C, 2009, 113, 3998-4007.

[10] R. Zeng, T. Zhang, G. Dais and B. Zou, Highly Emissive, Color-Tunable, Phosphine-Free Mn:ZnSe/ZnS Core/Shell and Mn:ZnSeS Shell-Alloyed Doped Nanocrystals, 2011, 115, 3005-3010.

[11] Y.-C. Zhu and Y. Bando, Preparation and photoluminescence of single-crystal zinc selenide nanowires, Chem. Phys. Lett., 2003, 377, 367-370.

[12] C.-H. Su, M. A. George, W. Palosz, S. Feth and S. L. Lehoczky, Contactless growth of ZnSe single crystals by physical vapor transport, J. Cryst. Growth, 2000, 213, 267-275.

[13] H. Kato, H. Udono and I. Kikuma, Growth and characterization of Br-doped ZnSe single crystals grown by a vertical sublimation method, J. Cryst. Growth, 2001, 229, 79-86.

[14] Y. P. Leung, W. C. H. Choy and T. I. Yuk, Linearly resistive humidity sensor based on quasi one-dimensional ZnSe nanostructures, Chem. Phys. Lett., 2008, 457, 198-201.

[15] M. A. Haase, J. Qiu, J. M. Depuydt and H. Cheng, Blue-green laser diodes, Appl. Phys. Lett., 1991, 159, 1272-1274.

[16] M. Kazes, D. Y. Lewis, Y. Ebenstein, T. Mokari and U. Banin, Lasing from Semiconductor Quantum Rods in a Cylindrical Microcavity, Adv. Mater., 2002, 14, 317-321.

[17] N. Kouklin, L. Menon, A. Z. Wong, D. W. Thompson and J. A. Woollam, Giant photoresistivity and optically controlled switching in self-assembled nanowires, Appl. Phys. Lett., 2001, 79, 4423-4425.

[18] J. Zhu, Y. Koltypin and A. Gedanken, General sonochemical method for the preparation of nanophasic selenides: synthesis of ZnSe nanoparticles, Chem. Mater., 2000, 12, 73-78.

[19] B. Ludolph and M. A. Malik, Novel single molecule precursor routes for the direct synthesis of highly monodispersed quantum dots of cadmium or zinc sulfide or selenide, Chem. Commun., 1998, 1849-1850.

[20] F. T. Quinlan, J. Kuther, W. Tremel, W. Knoll, S. Risbud and P. Stroeve, Reverse micelle synthesis and

characterization of ZnSe nanoparticles, Langmuir, 2000, 16, 4049-4051.

[21] S. Jana, I. C. Baek, M. A. Lim and S. Seok, ZnSe colloidal nanoparticles synthesized by solvothermal method in the presence of $ZrCl_4$, Journal of colloid and interface science, 2008, 15, 473-477.

[22] D. Han, C. Song and X. Li, Microwave-assisted synthesis of ZnSe of various morphologies using alkylamines as ligating solvent, Mater. Chem. Phys., 2009, 116, 41-45.

[23] M. Y. Nassar and I. S. Ahmed, Hydrothermal synthesis of cobalt carbonates using different counter ions: An efficient precursor to nano-sized cobalt oxide (Co_3O_4), Polyhedron, 2011, 30, 2431-2437.

[24] M. Y. Nassar and I. S. Ahmed, Template-free hydrothermal derived cobalt oxide nanopowders: Synthesis, characterization, and removal of organic dyes, Mater. Res. Bull., 2012, 47, 2638-2645.

[25] M. Y. Nassar, Size-controlled synthesis of CoCO 3 and Co 3 O 4 nanoparticles by free-surfactant hydrothermal method, Mater. Lett., 2013, 94, 112-115.

[26] M. Y. Nassar and M. Khatab, Cobalt ferrite nanoparticles via a template-free hydrothermal route as an efficient nano-adsorbent for potential textile dye removal, RSC. Adv., 2016, 83, 79688-79705.

[27] M. Y. Nassar, I. S. Ahmed, T. Y. Mohamed and M. Khatab, A controlled, template-free, and hydrothermal synthesis route to sphere-like α-Fe 2 O 3 nanostructures for textile dye removal, RSC. Adv., 2016, 24, 20001-20013.