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Optical properties of Zinc Sulfide Nanocrystal Embedded in Aerogel Matrix and its Synthesis

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ABSTRACT *ZnS semiconductor nanocrystals were synthesized by sol-gel technique at room temperature and embedded in an aerogel matrix. Synthesized sample were characterized by UV-Vis-NIR JASCO V-670 is spectrophotometer, scanning electron microscope (SEM), the photoluminescence (PL) spectrometer. UV-Visible is optical absorption spectra shows the red shift of the absorption characteristics of the sample in which ZnS was incorporated in the aerogel which might have occurred due to the increase of the particle size of the synthesized nanoparticles. PL measurements results show that both the samples exhibit PL emission the UV regions and the enhancement in PL emission is observed in the ZnS with aerogel sample. Moreover, PL emission spectra of the ZnS with aerogel sample show a red shift due to increasing particle size.*

INTRODUCTION:

Sol-gel chemistry is a extensively used technique for creation of glasses and ceramic materials on the other hand investigations on synthesis, properties and various applications of semiconducting nanocrystals (NCs). However, combining these two branches of research could lead to the development of new materials to replace environmentally unsafe solid-state lighting components [1]. The search for a cost-efficient and environmentally friendly alternative to traditional phosphors highlights the interest in placing the highly efficient luminescent semiconductor (NCs) in a stable material. Aerogels are meso/nanostructured, open pore materials with many unusual properties including transparency, high thermal resistance, very low refractive index and sound velocity and high surface area. Although aerogels have been formed from metal oxides, polymers and carbon, the most interesting composition is silica. It is used as a kinetic energy absorber ; it can be protect motor interesting composition is silica [2]. It is used as a kinetic energy absorber; it can protect motor vehicles and sensitive equipment, as a drug delivery system, and in microelectronics. Silica aerogels posses pores of all sizes. However, the majority of the pores fall in the mesopore regime, with relatively few micropores. The silica coating has already been applied to CdS and ZnS semiconductor NCs and metal, inorganic, and polymer colloidal particles. Such porous materials have maximum possible amount of surface area and it could be enable every embedded nanocrystals to sense the environment independently [3].

Synthesized sample are characterized by using an UV-Vis-NIR JASCO V-670, PL spectrophotometer and the microstructure of the samples are determined by the SEM. The average size of the agglomerate is found below 100 nm for ZnS and Zns incorporated in aerogel samples as the particle size measurement is limited by the resolution of the SEM. For getting actual particle size the measurements by TEM is required [4]. Further, from the PL study it is found that both the sample exhibit PL emission in UV region and the PL emission band from ZnS incorporated in aerogel sample is red shifted in comparison to that obtained in the ZnS sample without aerogel [5].

EXPERIMENT:

The synthesis is carried out at room temperature of 25 . At first, 10ml solution of both zinc nitrate solution is vigorously stirred using a magnetic stirrer up to 1hr, then solution of sodium sulphide are mixed with the solution of zinc nitrate drop wise. The white precipitate is separated from the reaction mixture by centrifugation for 5 in at 10,000 rpm and washed several times with water to remove all sodium particles. For the preparation of aerogel matrix, appropriate amounts of tetraethyl orthosilicate (TEOS), isopropanol, and 0.001 M sulphuric acid for acidification of the solution are mixed and stirred for 1h and then the gel is kept in a Petri disk for 30 m in. After that we mixed the separately prepared ZnS and aerogel and kept it for 24 h. The sample is further air dried at room temperature for further characterization of its nanostructural and optical properties.

RESULTS AND DISCUSSIONS:

For SEM study, a few drops of solution containing samples are dropped onto a glass slide, and the residue is removed by a filter paper beneath the glass plate. The SEM image of ZnS and ZnS with aerogel is shown in figure (a) and (b) respectively. From the SEM images, it is clear that the particle size for both the samples are well below 100nm however for obtaining the exact information for the particle size TEM characterization is required. Measured particle sizes of the samples from SEM image are the size of the agglomerates for both the sample. UV-V is optical absorption spectra of the prepared sample are shown in figure (c). For obtaining the UV-V is absorption characteristics samples are dispersed in methanol by ultrasonication and kept in quartz cuvette of path length 10mm. UV-V is optical spectra showed the red shift of the absorption characteristics of the sample in which ZnS is incorporated in the aerogel and this might have occurred due to the increase of the particle size of the synthesized NCs.

Photoluminescence (PL) emission characteristics of the samples are also determined at room temperature by using a PL spectrometer by using a PL spectrometer. For obtaining the PL emission characteristics samples are dispersed in methanol by ultrasonication and kept in a four side polished quartz cuvette of path length 10 mm. PL spectra of both the samples obtained at the excitation wavelength of 250 nm is shown in fig (d). From figure (d), it is found that a broadened PL mission in the UV region

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peaked at ~332nm is appeared in the prepared ZnS sample while the PL band is red shifted for ZnS with aerogel sample. This red shift occurred due to the porosity of aerogel NCs grow to bigger sizes. Besides, the increase in particle size leading to red shift of the PL emission peak is consistent with the observation of the red shift of the UV-V is absorption spectra.

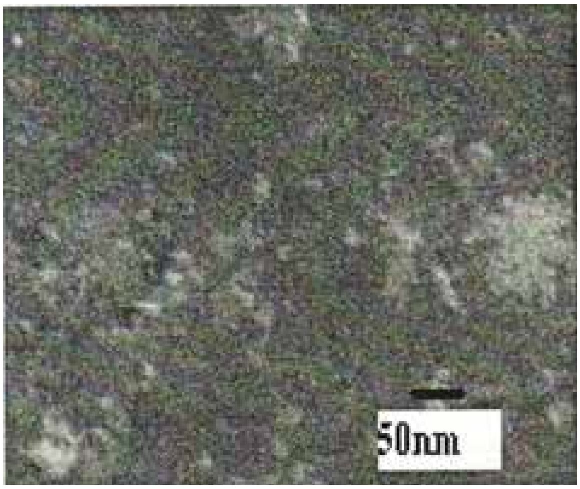

Fig. (a): SEM of ZnS

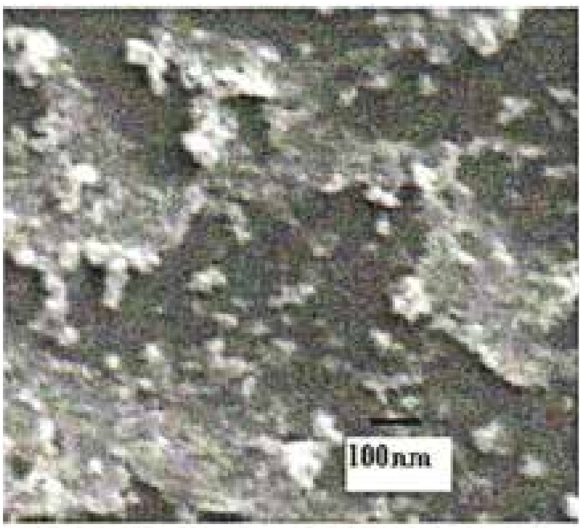

Fig. (b): SEM image of ZnS with aerogel

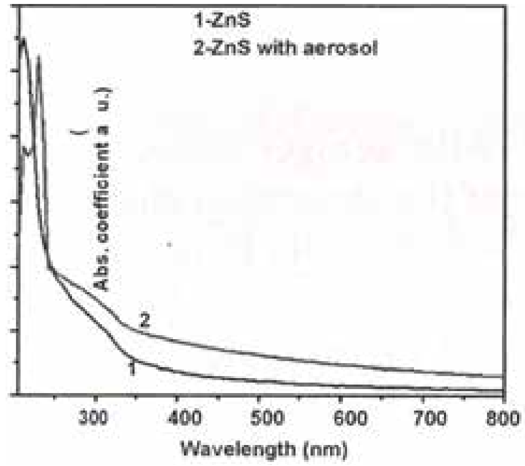

Fig. (c): UV-V is absorption characteristic of ZnS and ZnS with aerogel

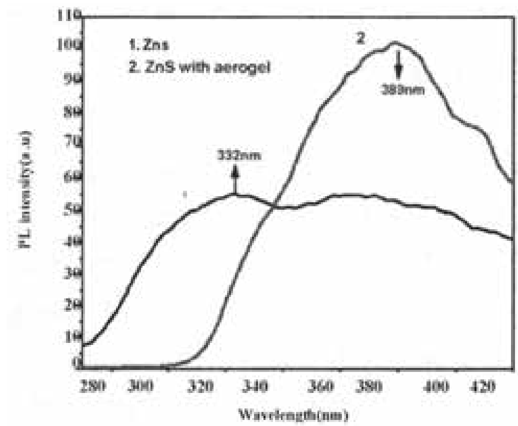

Fig. (d): PL spectra of ZnS and ZnS with aerogel

CONCLUSION:

We have successfully synthesized ZnS and ZnS with aerogel nanocrystals by sol-gel process. UV-V is optical spectra show the red shift of the absorption characteristics of the sample in which ZnS is incorporated in the aerogel which might have occurred due to the increase of the particle size of the synthesized NCs. In PL spectra a broader PL emission occurred peaked at 332nm for the ZnS sample at 250 nm excitation. While an enhanced (about two times) PL emission intensity with a peak at 389 nm is observed in ZnS with aerogel sample under the same excitation wavelength. The materials being highly luminescent and have large surface area may be applicable in different optoelectronic devices.

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