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Optical And Structural Properties Of Pbs Nanoparticles Embedded In Starch

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Abstract:

Pbs nanoparticles are synthesized in the polymer matrix, starch, by means of chemical method. The samples are prepared by varying pH, temperature and rotation time of the stirrer. The crystalline structure of the nanoparticles is studied by X-ray measurements. The average size of the nanoparticles and their crystalline structure are determined from the transmission electron microscopy and electron diffraction patterns, respectively. The optical properties of the samples are studied by UV-Vis spectroscopy. The absorbtion spectra of the samples display exciton absorbtion bands at much higher energy than the fundamental absorbtion bands of the bulk PbS. This result is a consequence of strong quantum confinement effects produced by the reduced size of the PbS nanoparticles as compared to exciton Bohr diameter of the bulk PbS.

Introduction

Semiconductor nanocrystals show characteristics which are completely different from those of bulk materials. The nanoclusters with extremely small size having quantum confinement effects are known as quantum dots. The dimension of these confined particles approaches the exciton Bohr radius. PbS nanoparticles is an interesting material with an exciton Bohr radius of 9 nm and a bulk bandgap of 0.41 eV at (300K) , corresponding to an optical cut-off at 3020 nm[1]. By decreasing the size of the nanoparticles from micron to nanoscale, the band-gap of the PbS nanoparticles can be enlarged from 0.41 eV to 5eV[2]. Studies are going on for the fabrication of PbS nanoparticles through different methodsand employing Poly(vinyl alcohol), poly(vinyl pyrrolidone), gelatin and DNA etc as stabilizers.This paper presents the optical and structural properties of PbS nanoparticles using starch as stabilizer.

Experimental Section

Materials

Starch soluble extra pure, $Pb(NO_3)_2$ (assay $\geq 99\%$),Na_2S(assay 55-58%) were purchased from Merck Specialities Private Limited and used as received. The water used is distilled.

Synthesis Of Semiconductor Nanocrystals

The PbS nanoparticles are fabricated through chemical route [3]. The matrix used is starch.The samples prepared are kept overnight and characterization are done either with liquid samples or casting the samples over glass substrates.UV-Vis analysis is done by Hitchi U-3210. The HR-TEM is done by the instrumentJEOL JEM2100. The XRD analysis is done by BRUKER D8ADVANCE.The Photoluminesence is done by LS 55.

Experimental Results And Discussions

(i) UV-Vis study: The absorption edge of the different samples from UV-Vis curves shown in fig1(a) are found between 550 and 600 nm[4]. The band gap calculated from Tauc's method shows the presence of blue shift from the corresponding bulk value(0.41eV) and suggests quantum confinement fig1(b).

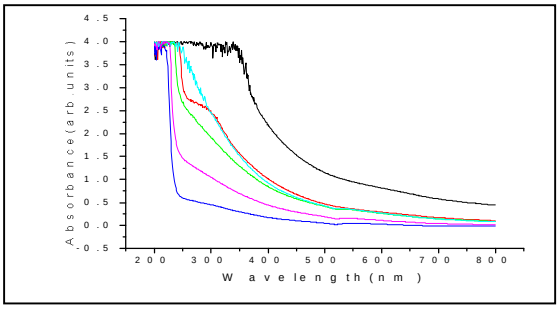

Figure 1(a): UV-Vis spectra for the samples

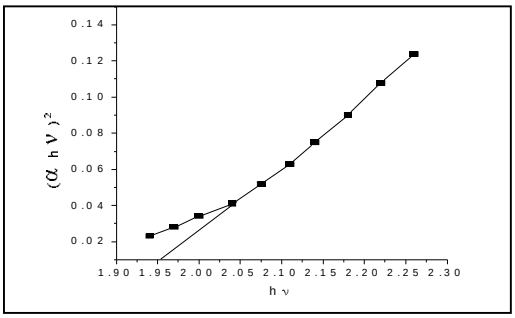

Figure 1 (b): Calculation of band gap from Tauc's method

(ii) Photoluminescence: The PL peak is found to be at 568 nm which is highly blue- shifted from the corresponding bulk value(band-gap energy of the bulk PbS is 0.41 eV, λ_{max}=3020 nm)

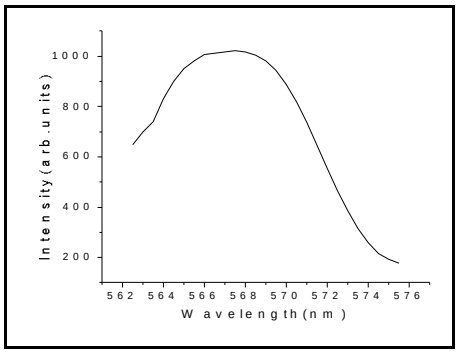

Figure 2: PL spectra of sample S2

(iii) XRD analysis: Fig3 shows the XRD pattern of the sample S2 . The prominent peaks are found to be at 2θ=24.9,30.03 and 43.1 which corresponds to the planes having Miller indices (111), (220)and $(200)^2$.

The mean cluster size can be calculated from the Scherrer's formula [1] is 5.4nm

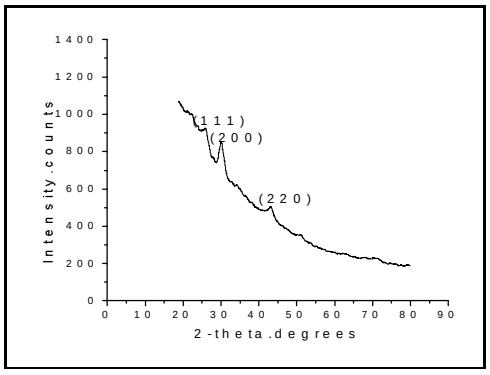

Figure 3: XRD analysis of a sample (S2) of PbS

HR-TEM: Fig 4 depicts the HR-TEM images of the sample S2. The morphology of the nanoparticles is depicted from these pictures. The images show that most of the particles are spherical in shape with an average diameter of ~8nm. The picture clearly shows the lattice a plane of the crystal with d-spacing of 0.22nm.Agglomeration of some particles is also observed.

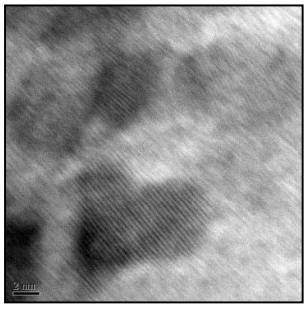

Figure 4(a):Estimation of the size of the particle

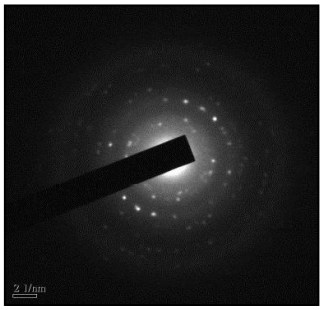

Figure 4(b): SAED image of a nanoparticle

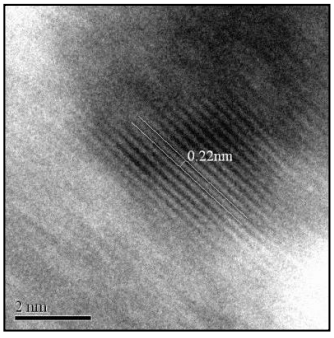

Figure 4(c): Image showing the lattice planeswith the d-spacing

Conclusion

UV-Vis results reveal blue shift of the as-prepared samples. XRD results indicate the average size of ~5.4 nm whereas HR-TEM shows size of ~8 nm with clear lattice planes. Thus we have successfully synthesized PbS quantum dots in starch having strong confinement.

Acknowledgement

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