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Synthesis and Characterization of CdS and Ag Doped CdS Nanoparticle

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Abstract: ***In the present work, a systematic study has been carried out to understand the influence of Ag doping on the structural and optical properties of CdS nanoparticles. CdS and Ag doped CdS nanoparticle have been prepared by chemical method. The X-ray diffraction method analysis reveals that both undoped and Ag doped CdS nanoparticle exhibit hexagonal structure. The surface morphology of CdS and Ag doped CdS nanoparticle have been studied using scanning electron microscope (SEM). The optical absorption spectra of Ag doped CdS nanoparticles also exhibit red shift with respect to that of CdS nanoparticle.***

Keywords: Chemical method, Ag doped CdS nanoparticle, X-ray diffraction, Optical properties, and Scanning electron microscope.

1. Introduction

Nanotechnology is the understanding and control of matter of dimensions of roughly 1 to 100 nanometers. It is the act of purposefully manipulating matter at the atomic scale, otherwise known as nanoscale. In the nanotechnology, a particle is defined as a small object that behaves as a whole unit in terms of its transport and properties. Nanoparticle may or may not exhibit size – related properties that differ significantly from those observed in fine particle or bulk materials (1,2). The interesting and sometimes unexpected properties of nanoparticles are therefore largely due to the large surface area of the material.

Nanotechnology is growing day by day because of its advantages in the field of medicine, diagnostics, drug delivery, tissue engineering, chemistry and environment, displays etc. The synthesis and characterization of metal nanoparticles have attracted a great deal of attention due to their potential applications in many fields. Quantum confinement is a very successful model for describing the size dependent electronic structure of nanometer sized semiconductor structure. When the materials are so small, their electronic and optical properties deviate substantially from those of bulk materials (4-10).

The synthesis of nanomaterial can be well accomplished by two approaches namely “Bottom up” and “Top down”. Nanomaterials have been prepared by using different technique such as VLS growth, hydrothermal route, surfactant assistant approach etc. Compared with other techniques chemical method uses an environmental friendly reaction medium and it has many advantages. The chemical method is simple and cost effective technique which has been adopted for synthesis of nanoparticles. So here we have used a chemical route for synthesis of CdS nanoparticles (11). The present paper reports the synthesis of Ag doped CdS nanoparticle, scanning electron microscope (SEM), X-Ray diffraction pattern (XRD) and also the analysis of the optical spectra.

2. Experimental Method

Chemical synthesis of Ag doped CdS nanoparticle has been carried out by chemical precipitation method. Similar to that used by P. kavitha *et.al* (12).

To prepare Ag doped CdS nanoparticle, cadmium acetate (2g) which was dissolved in 50 ml of distilled water and the solution was stirred for 30 min at room temperature. After the stirring process silver nitrate (0.4 g) was added to the solution. After 30 min stirring process 2 ml of ammonia solution was introduced and PH of the solution is fixed at 9. This solution was stirred for an hour at room temperature .The process was then followed by addition of sodium sulfide (0.6g) precursor in to the solution .Soon after the introduction of Na_2S the entire solution changed into deep yellow. Then the entire solution starts to precipitate and settle down within few seconds. The solution becomes turbid as the precipitation process takes place the stirring is confirmed till the addition of sodium sulfide if over. Then the nanoparticles are then separated by centrifugal process and washed thoroughly with ethanol to gid rid of unreacted materials from the products. The particles are then collected in a Petri dish and dried by keeping the material in a hot air oven for 6 hours duration with the temperature of 120^0C. The process is repeated for different concentration of precursors. Then the free standing powder collected and preserved in an air tight container. The samples are characterized by scanning electron microscope and optical absorption spectra.

3. Result and Discussion

Structural Analysis

X-ray diffraction studies

XRD is a very important experimental technique that has long been used to address all issues related to the crystal structure of solids , including lattice constants and geometry, identification of unknown materials etc., Fig 1 (a) shown the powder X-ray diffraction pattern of pure CdS nanoparticle. The diffraction peaks positioned at 2θ values of 24.82^0 ,26.52^0 ,28.20^0 ,36.62^0 ,43.72^0 and 52.85^0 match well with

hexagonal wurtzite phase of CdS (JCPDS card no.89-2944) and can be indexed respectively to the (1 0 0), (0 0 2), (1 0 1), (1 0 2), (1 1 0) ,(2 0 1) crystal planes.

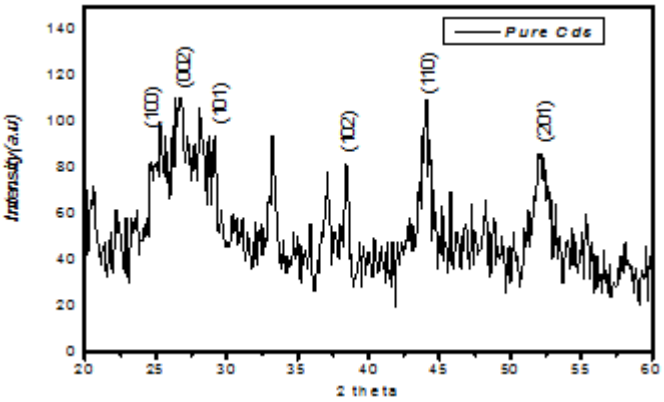

Figure 1: (a) XRD pattern of pure CdS

Fig 1 (b) shows XRD diffraction pattern of various concentration of Ag doped CdS nanoparticle. The prominent new peaks appeared at 2θ values 38.11^0 corresponds to silver and it is match well with JCPDS Card no.04-0783. The other prominent peaks also appeared at various 2θ values (24.82^0, 28.20^0, 36.64^0, 44.87^0, 52.85^0). This 2θ value of Ag doped with CdS nanoparticle are compared with pure CdS, the intensity slightly increased for various concentration of Ag doped with CdS. This indicates the formation of Ag nanoparticle in CdS. It conforms structure of Ag doped CdS nanoparticle is hexagonal.

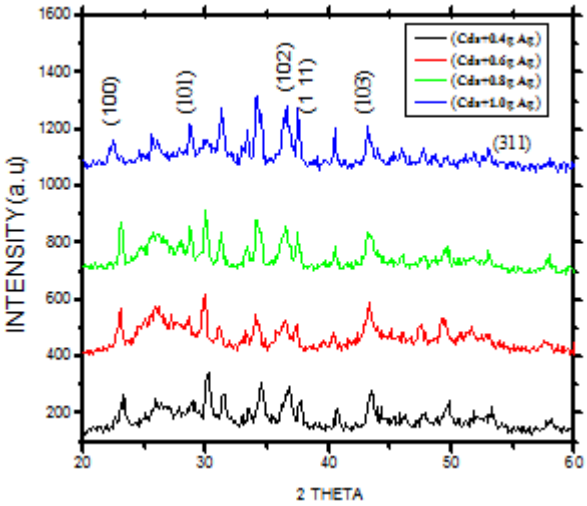

Figure 1: (b) XRD pattern of Ag doped CdS

The crystalline size D of the nanoparticle was found from the peak width with the Scherer's formula $D= 0.94\lambda / \beta \cos\theta$, Where D is the average crystalline size, λ is the X-ray wavelength, β is the full width half maximum (FWHM) of the diffraction peak, θ is the diffraction angle. The average particle size is found to be 27 nm. All the reflections can be assigned to the standard pattern for the hexagonal phase of Ag doped CdS nanoparticle with lattice constants a=9.3401 and c=7.8518.

4. Optical Studies

UV-Visible Analysis

The optical absorption spectra of CdS and Ag doped CdS nanoparticle was recorded as a function of wavelength in the wavelength range 200-900 nm. Fig(2 a,b,c,d,e) shows the UV-Visible absorption spectra of CdS nanoparticles undoped and doped with different concentrations of Ag.

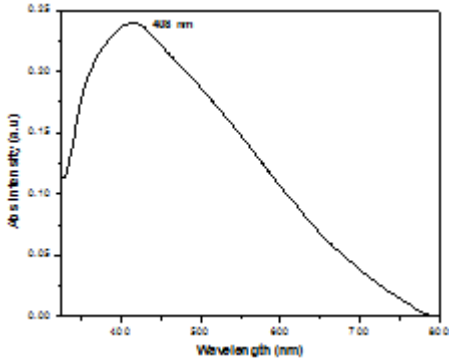

Figure 2: (a) UV spectra of CdS

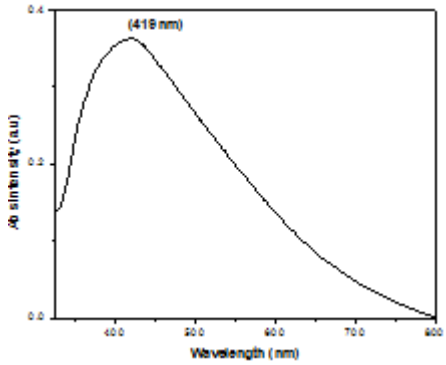

Figure 2: (b) UV spectra of Ag doped CdS (0.4 g)

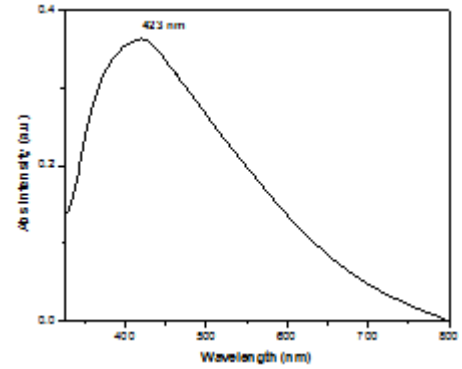

Figure 2: (c) UV spectra of Ag doped CdS (0.6 g)

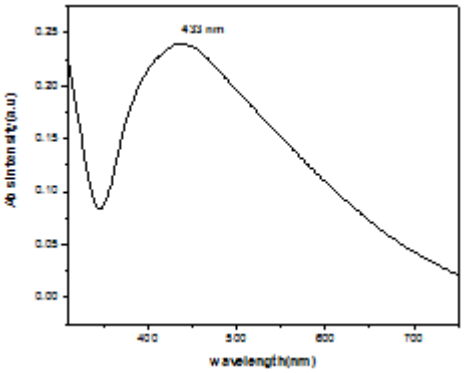

Figure 2: (d) UV spectra of Ag doped CdS (0.8 g)

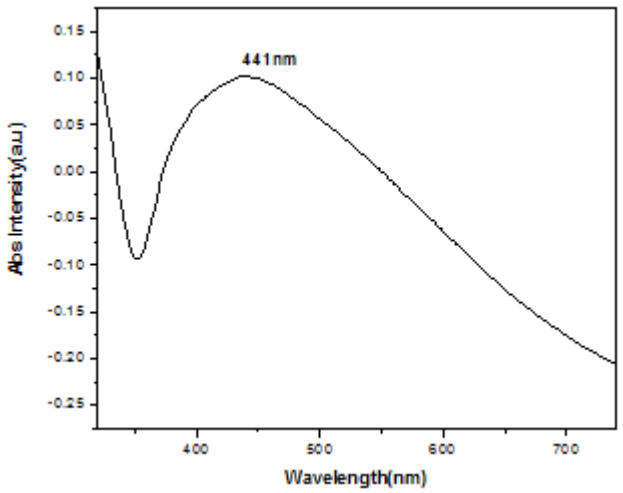

Figure 2: (e) UV spectra of Ag doped CdS (1 g)

The absorption spectra of the samples are very strong and show long absorption tails due to light scattering at high concentration of nanoparticle. The absorption onset wavelengths of pure CdS and at different doping concentrations of silver namely Ag (0.4), Ag(0.6), Ag(0.8), Ag (1.0) are 408, 419, 423, 433, 441 nm respectively, which are all blue –shifted compared with the absorption of bulk CdS which is 515 nm. This because of quantum confinement effect. Also a slight red-shifted has been observed in the absorption edge on doping the nanoparticles with Ag. But no appreciable broadening or shift in the absorption band suggests that the interaction of the silver metal atoms with the CdS is week, and no surface plasmonic effects emerged on silver doping. Higher concentrations of Ag should be tried to study the effects more prominently. The band gap of nanoparticle has been calculated from the differential minima of the absorbance curve. The band gap values of the pure and Ag doped CdS nanoparticles are less than that of the bulk value of 3.42 eV.

Fourier Transform Infrared (FTIR) Spectroscopy

The formation of CdS and Ag doped CdS nanoparticle was examined by recording their FTIR spectra in the range 4000 to 500 cm^{-1}. Powdered samples were used in FTIR Spectrum BX-II (Perkin Elmer) spectrometer, without any further specimen preparation. Figure 3(a) shows the FTIR Spectrum for CdS and Ag doped CdS nanoparticle.

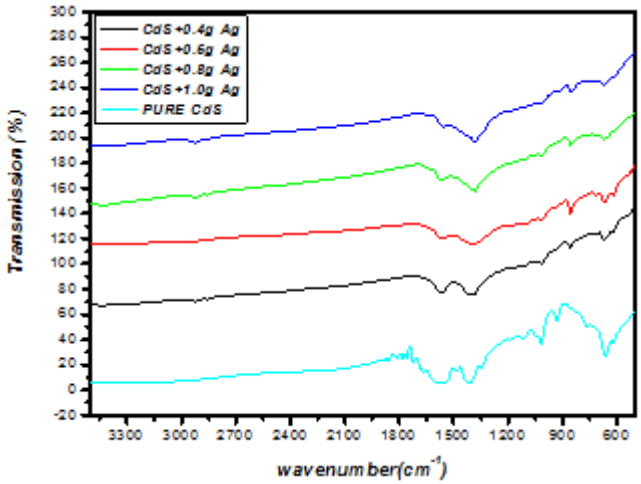

Figure 3: (a) FTIR spectra of Ag doped CdS

The peak at 1410.89 cm^{-1} in pure CdS due to C-C bonds becomes narrower and shift to 1388.19 cm^{-1}after the formation of Ag doped CdS. The functional group of Ag exhibited prominent peak at 1381.18 cm^{-1} . The band observed at 1645.76 cm^{-1} due to O-H bending mode of vibration of CdS becomes narrower and shift to 1539.35 cm^{-1} after the formation of Ag doped CdS nanoparticle. The peaks at 1017.08 cm^{-1} , 1024.87 cm^{-1} and 1115.70 cm^{-1} due to C-C stretching of CdS nanoparticle .The peaks at 669.33 cm^{-1} and 608.34 cm^{-1} corresponds to of O-H bending vibration of CdS. No appreciable change has been observed for other peaks. This confirms the coordination and conjuction of Ag doped CdS nanoparticles.

5. Surface Morphology Studies

SEM Analysis

Surface morphology of CdS and Ag doped CdS nanoparticle were done using Scanning Electron Microscope(SEM).The morphology of CdS and various concentration of Ag doped CdS nanocomposites are shown in fig(4 a,b,c,d,e).

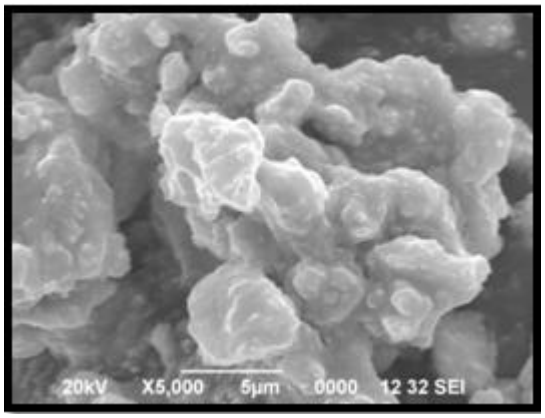

Figure 4: (a) SEM images of CdS

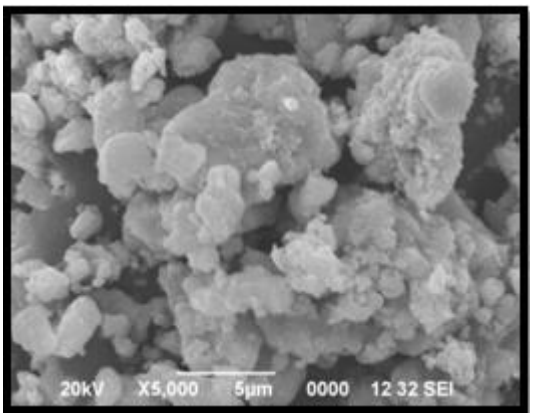

Figure 4: (b) SEM images of Ag doped CdS (0.4 g)

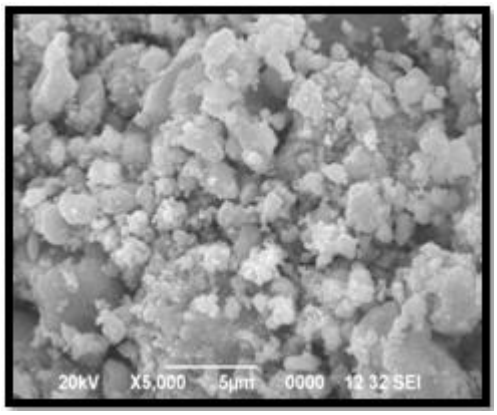

Figure 4: (c) SEM images of Ag doped CdS (0.6 g)

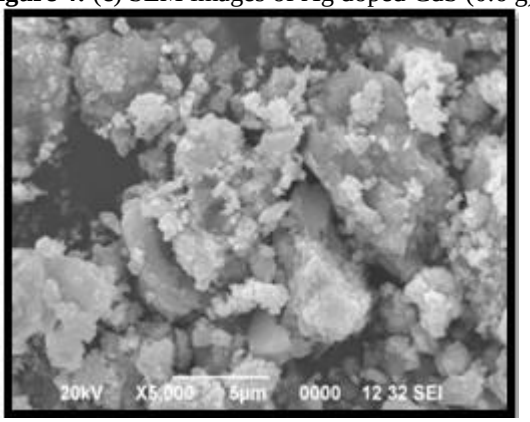

Figure 4: (d) SEM images of Ag doped CdS (0.8 g)

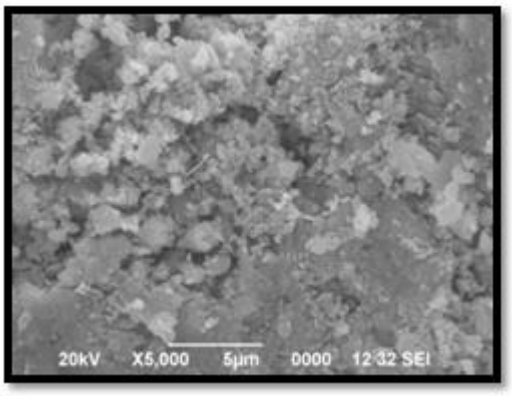

Figure 4: (e) SEM images of Ag doped CdS (1 g)

From the SEM images, we observed that the particles are uniformly distributed. The SEM images of CdS and Ag doped CdS nanoparticle confirms the existence of very small crystalline nanoparticle. The particle size and distribution of nanoparticle mainly depends upon the doping concentration. The SEM images of CdS nanoparticle reveals that the flower like structure. The Ag doped with CdS nanoparticle, the structure of CdS is flakes like structure. When the concentration of Ag is increased, the structure of CdS becomes cluster form. It can be clearly seen that the size of the CdS and Ag doped CdS nanoparticle increases rapidly with increase in molar concentration, however, the diameter of the nanocomposites increases slowly. The size of the CdS and Ag doped CdS nanoparticle can be controlled by molar concentration. The average particle size is found to be 28 nm which was calculated by using image J software. The result is compare with the particle size of 27 nm which was calculated by using XRD analysis.

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