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Effect of thermal annealing and gamma irradiation on the optical properties of CdS-polymer nanocomposites

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This paper presents formation of CdS nanoparticles in gelatin polymer matrix using successive ionic layer adsorption and reaction (SILAR) technique and the effects of thermal annealing and gamma irradiation on the optical properties of CdS-polymer nanocomposites have been investigated. It has been determined that optical transparency of CdS-gelatin nanocomposites decreased with thermal annealing and gamma irradiation. It has been also observed a small red shift in band gap of CdS due to agglomeration of nanoparticles after treatment. SEM images also show the formation of CdS nanoparicles in polymer matrix with average particles size of about 30nm.

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1. Introduction

Recently chalcogenide semiconductor nanocomposites have attracted a great deal of attention due to their interesting properties that can not be obtained from their bulk materials [1,2]. These chalcogenide semiconductor-polymer nanocomposites have perspective applications in areas such as photovoltaic and optoelectronic device technology [3,4]. There are several methods for the preparation of CdS- polymer nanocomposites including Chemical Bath Deposition [5], ultrasonic irradiation [6] and other methods [7-10]. One of the most interesting fields for semiconductor nanoparticles is their incorporation within polymers. Semiconductor-polymer nanocomposite based devices have advantages over fully organic or fully semiconductor counterparts. Also in semiconductor polymer nanocomposites there is the opportunity to tailor the band gap of the semiconductor component simply by changing of nanoparticles size.

In this work, optical absoption spectroscopy was employed to study the effect of thermal annealing and gamma irradiation on CdS- polymer nanocomposites. In addition we also discuss the effect of gamma irradiation and thermal annealing on optical properties of CdS-polymer nanocomposites prepared by (SILAR) technique.

2. Experimental

The preparation of CdS-polymer nanocomposites were carried out by the SILAR technique, whose details can be found elsewhere [11]. Materials for the growth of CdS nanoparticles in gelatine matrix where: Cadmium acetate dihydrate ($C_4H_6CdO_4.2H_2O$ extra pure), Sodium sulfure ($Na_2S.xH_2O$, Purity ≥ 98%), sodium hydroxide (NaOH extra pure), Tartaric acid ($C_4H_6O_6$ ≥ 99.5%), were obtained from Merck and directly employed without purification. All of the synthesis and rinsing processes were carried in water media.

The SILAR technique is mainly based on immersion of the substrate into separate cation and anion precursor solutions and rinsing between every immersion with ion exchange water to avoid homogeneous precipitation.

Fig. 1 shows the schematic representation for the deposition of CdS films by SILAR technique.

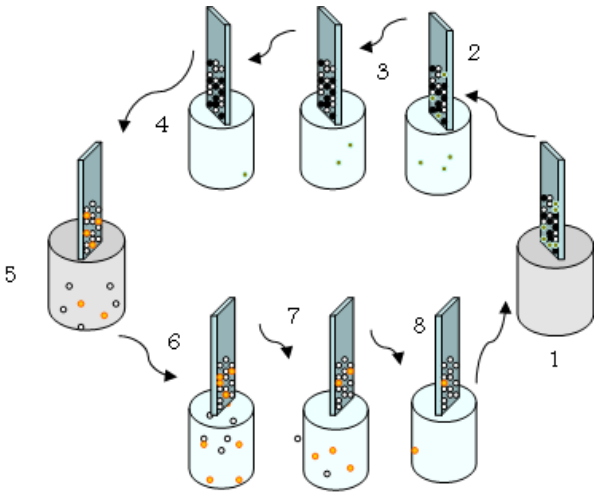


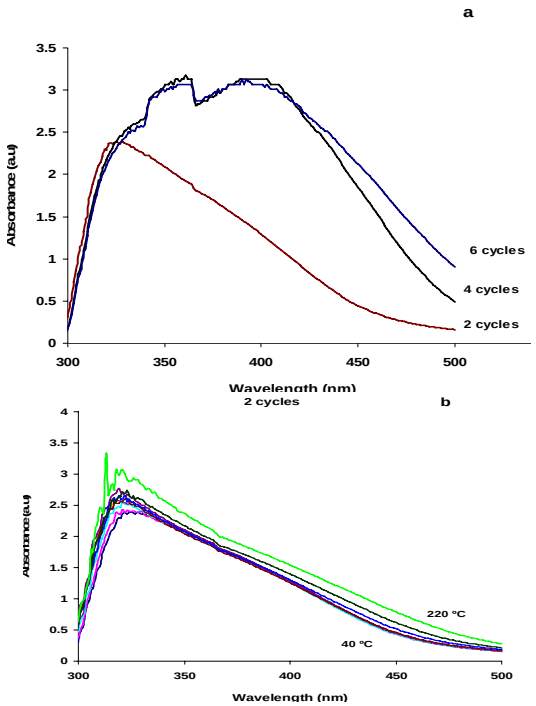
Fig. 1. The schematic of SILAR technique for deposition of CdS nanoparticles , (1) cationic precursor (Cadmium acetate) , (5)anionic precursor(Na_2S), (2,3,4,6,7,8) distilled water.

Gelatin coated on ordinary microscope glass slides was used as a substrate and porous media.

0.2 M cadmium acetate solution was prepared by dissolving $C_4H_6CdO_4.2H_2O$ in distilled water as a cationic precursor and the pH value of solution was 5. Also 0.2 M sodium sulfite was prepared by dissolving $Na_2S.xH_2O$, in distilled water as anionic precursor with the pH value of 12. The gelatin coated substrate were immersed in cationic precursor for 30s in order to adsorption of cadmium ions on the substrate surface. The substrate rinsed in distilled water for tree times (time of rinsing for each time was 20 s) to remove loosely bound species of Cd^{2+} ions. Then the substrate was immersed in anionic precursor solution for 30 s, for the sulfure ions (S^{2-}) to react with the pre-adsorbed Cd^{2+} ions to formed CdS nanoparticles in gelatin polymer substrate. The weak bounded ions were removed by rinsing the substrate in distilled water for 20 s in each baker. By using this process one cycle was completed. These cycles were repeated until desired conditions were reached.

UV-vis absorption spectroscopy is a useful technique to monitor the optical properties of the nanoparticles. Generally, the wavelength at the exciton absorption decreases with the decrease of particle size, as a consequence of quantum confinement of the photogenerated charge carriers.

Fig 2a) shows the UV-vis absorption spectra of the CdS-polymer nanocomposites prepared by SILAR method. The spectra of all samples consist of a long wavelength tail and absorption maximum. The value of the optical band gap for the CdS-polymer nanoparticles with 2, 4 and 6 cycles of SILAR have been estimated to 2.42, 2.49 and 2.97eV respectively[11]. The blue shift of the absorption spectra is attributed to the quantum confinement of charge carriers in the nanoparticles.



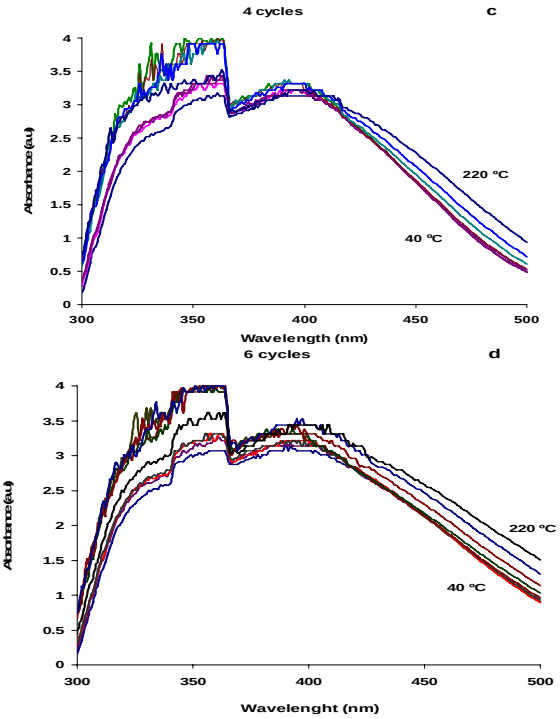
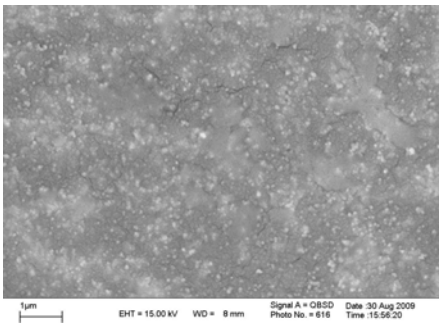
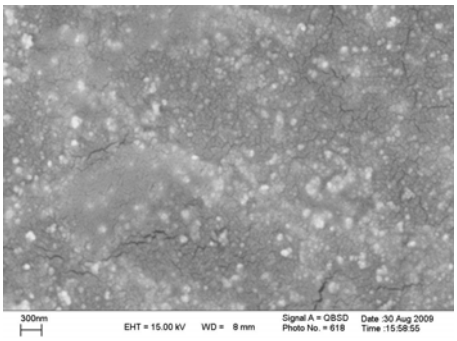


Fig. 2. (a) Uv-vis absorption spectra of the CdS-polymer nanocomposite without thermal annealing and gamma irradiation, b, c and d) after thermal annealing and gamma irradiation for 2, 4 and 6 cycles of SILAR, respectively.



(a)



(b)

Fig. 3. (a) and (b) SEM images of the CdS-Polymer nanocomposites at different magnifications.

The effect of thermal annealing and gamma irradiation on the optical properties of CdS-Polymer nanocomposite has been presented in Fig. 2 (b), c and d in different temperatures from 40 to 220 C. As seen in Fig. 2 (a), (b) and (c), the peaks becomes a small red shifted and the intensity of the peaks increased compared to untreated samples (Fig. 2 (a)). This is expected because the annealing and gamma irradiation affects on the transparency of films and then nanoparticles aggregated to form nanoclusters. The SEM images of the samples after thermal annealing and gamma irradiation are shown in Fig. 3 (a) and (b) in different magnifications, which depicts the nanometric CdS particles formed. The average particles size estimated to 30nm.

3. Conclusions

In this study, CdS-Polymer nanocomposites were prepared using SILAR technique at room temperature and the effect of thermal annealing and gamma irradiation on the optical properties of CdS-Polymer nanocomposites was investigated. Blue shift in energy gap and SEM images confirms the formation of CdS nanoparticles in polymer matrix.

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