Synthesis and Characterization of Triethylamine (TEA) capped CdS nanoparticles

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1. INTRODUCTION

The synthesis and characterization of small particles of materials is currently an area of intense theoretical and experimental research. Over the past decade, the synthesis and functionalization of nanostructures have attracted great interest due to their significant potential application. Due to the quantum confinement effect and the large surface to volume ratio, nanocrystals show very special physical and chemical properties. However, the aggregation of nanocrystals always decreases their original nano-effects. During wet chemical synthesis of nanoparticles, organic stabilizers are usually used to prevent them from aggregating by capping their surfaces. Moreover, the introduction of stabilizers also influences on the chemical properties as well as physical properties of semiconductor materials, from stability to solubility and to light emission. Therefore, proper surface modification by stabilizers can remove the localized surface-trap states and significantly increases the quantum yield of the excitonic emission. Commonly used stabilizers are phosphine oxide, phosphates, various thiols, biomolecules and organic dendrons [1].

Cadmium Sulfide, a direct band gap material with Eg of 2.42 eV at room temperature can be used for photo electronic devices. It is an efficient window layer for the fabrication of solar cell structures due to its high transmittivity and low resistivity. In recent years, CdS nanostructural materials have been widely investigated. In the present work, CdS nanoparticles were prepared by wet chemical synthesis and triethylamine was used as a capping agent. The modified CdS nanoparticles will help us to study exactly the special physical and chemical properties of the nanomaterials and broaden its application.

2. EXPERIMENTAL

Nanoparticles of CdS were prepared at room temperature using ethanol as the solvent by dropping 10 ml of 2.5 M NaOH into the mixture of 25 ml of 0.5 M CdCl\textsubscript{2}.H\textsubscript{2}O and 25 ml of 0.5 M thiourea, which is kept, stirred vigorously using magnetic stirrer for 20 hrs. The role of triethylamine was to stabilize the particles against aggregation. Subsequently the resulting yellow solid product was centrifugalized and washed repeatedly using distilled water. The particles were finally dried at 50ºC for 2 days. The dried pure and capped CdS nanoparticles have been characterized by powder XRD, UV – Visible, FTIR, FTRaman and Photoluminescence spectral analyses.
3. RESULTS AND DISCUSSION

Figure 1 (a) and (b) shows XRD pattern of the uncapped and capped CdS respectively. The 3 peaks having 2θ values at 27.25°, 44.25°, 52.25° corresponds to (111), (220) and (311) planes of the cubic phase for uncapped CdS nanocrystals. The appearance of (102) and (103) peak in Figure 1(b) indicates the hexagonal CdS phase for capped CdS nanocrystals. This demonstrates that TEA has changed the structure of CdS from cubic to hexagonal. The peak broadening indicates the reduction in particle size. The particle size using the Debye-Scherrer Equation was calculated to be 2.43 nm and 1.89 nm respectively [2]. The optical absorption spectra (not shown) for the uncapped and capped CdS have been recorded and by applying EMA theory, the particle size was calculated to be 2.68 nm and 2.04 nm respectively. XRD results are almost in good agreement with results from optical absorption spectra.

Figure 2 shows PL spectra of uncapped and capped CdS. The spectrum displays two strong peaks at 601 nm and 628 nm, indicating red shift and may be attributed to trap emission. The Cd atoms are displaced to interstitial positions more easily than the sulphur atoms, because Cd atoms has a smaller binding energy than S atoms in the CdS lattice. This means that the observed red peak is mainly due to the excess Cd atoms [3,4].

The FTRaman spectra of the capped and uncapped CdS have been recorded and shown in the Figure 3. Raman line for nanoparticles are broader and frequency shifted compared to those of the bulk crystals and the additional line appeared in the spectra of the particles. This has been attributed to the finite size of the particles. Due to large surface-to-volume ratio of particles, the effective symmetry of particles will be appreciably different in comparison with the massive crystal [5]. One can clearly see two characteristics CdS longitudinal optical (LO) phonons peaks at about 299 cm$^{-1}$ (1LO) and 542 cm$^{-1}$ for uncapped CdS nanocrystals .The intensity of peaks for the capped CdS is higher than uncapped CdS. We observed a systematic downshift of 2 LO peak of the quantum dots from its bulk position. The red shift of the phonon peaks is due to spatial confinement of the phonon mode [6].
4. CONCLUSIONS

We have successfully prepared CdS nanoparticles by room temperature wet chemical synthesis using thiourea and cadmium chloride in gram quantities. It is observed that capping with triethylamine leads to the phase transformations from cubic to hexagonal. The optical absorption spectra and XRD reveals that the CdS crystallizes in nano region. The PL spectrum indicates the red shift. The low frequency modes in the FTRaman spectra capped and uncapped CdS have been identified and reported.

5. REFERENCES


