

**Research Article**

## SYNTHESIS OF CdTeSn (5%) QUANTUM DOTS

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### ABSTRACT

The comparison of growth processes and fluorescent properties of CdTeSn(5%) semiconductor quantum dots that are synthesized in different concentrations of  $\text{Sn}^{2+}$  in water are discussed in this paper. The samples are characterized through absorption (UV) and photoluminescence spectra (PL). The results show that when the reaction time is prolonged, the absorption peak and fluorescent emission peak present obvious red shifts and the diameters of the Quantum dots continuously increase.

**Keywords:** Quantum Dots, Modifier, Fluorescence

### INTRODUCTION

Research on semiconductor quantum dots has increased rapidly in the past few decades (Meng and Song, 2004). Luminescent semiconductor quantum dots have been intensely studied due to their unique optical properties (Chan and Nie, 1998). In particular, semiconductor Quantum dots are very attractive as biological labels because of their small size, emission tunability, superior photostability and longer photoluminescence decay times in comparison with conventional organic dyes (Bruchez *et al.*, 1998). These highly luminescent quantum dots have photophysical properties superior to organic dyes but the high temperature required to synthesize them can be problematic for some applications (Alivisatos, 1996). One of the major challenges is to obtain water-soluble Quantum dots with a high PL quantum efficiency (Colvin *et al.*, 1994). Arrested precipitation in water in the presence of stabilizers (e.g., thiols) is a faster and simpler method to synthesize water-soluble Quantum dots and has been applied to several semiconductors potentially relevant to biolabeling (e.g., CdS, CdSe, CdTe). For CdS and CdSe, this yielded Quantum dots with defect-related emission and a low quantum efficiency (Klimov *et al.*, 2000). For CdTe Quantum dots, both excitonic and defect-related emission bands were observed (Santra *et al.*, 2005). Although samples with no observable trap luminescence were also obtained. In this study, we report a novel method that yields highly luminescent water-soluble CdHgTe Quantum dots (Brus, 1986).

#### **Synthesis CdTeSn(5%) Quantum Dots**

In a typical synthesis 2.5 mmol of  $\text{CdCl}_2$ ,  $2.5\text{H}_2\text{O}$  and 5, 10.15 weight percent of  $\text{Sn}^{2+}$  is dissolved in 110 mL of water, and 12 mmol of the thiol stabilizer (TGA) is added under stirring, followed by adjusting the pH to appropriate values by dropwise addition of 1M solution of NaOH. The solution may be slightly turbid at this stage. The reaction mixture is placed in a three-necked flask fitted. Under stirring, NaHTe (a purple clear liquid generated by the reaction of 2.4 mmol of Te powder with 5 mmol  $\text{NaBH}_4$  in 8 mL water and stirring then cooling in an icebath for 10 min) is passed through the solution together for 20 min. CdTeSn(5%) precursors are formed at this stage. The precursors are converted to CdTeSn(5%) quantum dots by refluxing the reaction mixture at  $95^\circ\text{C}$  under nitrogen-gas conditions.

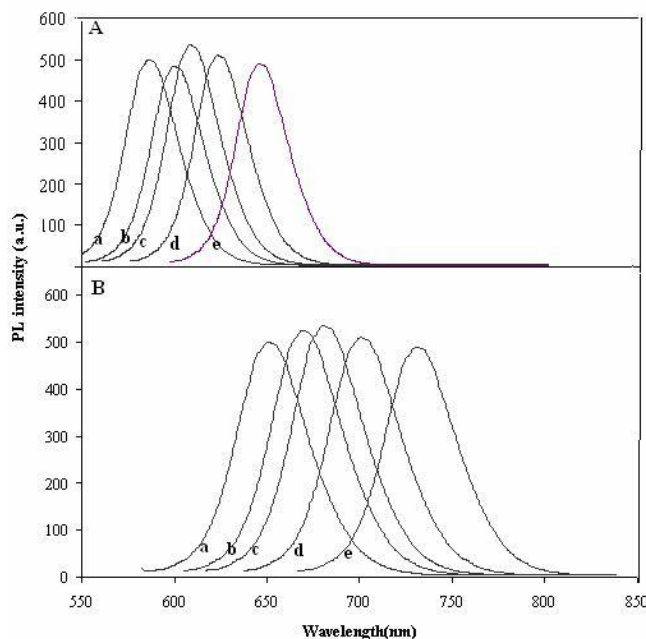
### RESULTS AND DISCUSSION

#### **Optical Properties of CdTeSn(5%) Quantum Dots**

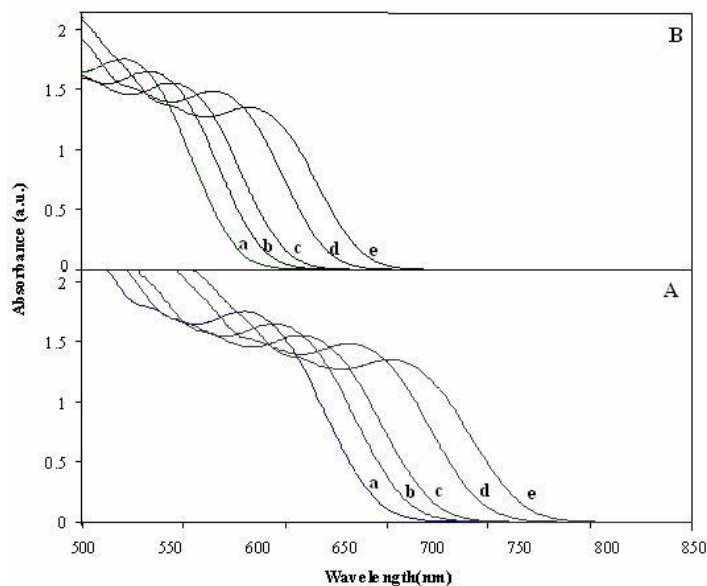
Figure 1, 2, 3 shows photoluminescence (PL) spectra and absorptions (UV) of a size series of CdTeSn(5%) quantum dots. The spectra were measured on as-prepared CdTeSn(5%) colloidal solutions which were taken from the refluxing reaction mixture at different intervals of time. A clearly resolved absorption maximum of the first electronic transition of CdTeSn(5%) Quantum dots appear which shifts to longer wavelengths as the particles grow in the reaction process. The size of the growing CdTeSn(5%) Quantum dots are further controlled by the duration of reflux and can easily be monitored by absorption and PL spectra. The PL excitation spectra also display electronic transitions at higher energies when the

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heating time is extended from 30 min to 300 min in the presence of thioglycolic acid is used as the stabilizer. PL technique allows detection of the luminescence emitted by particles with selected size.

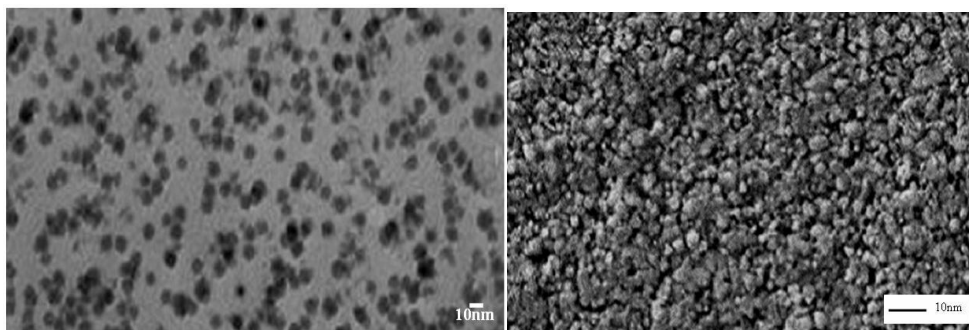


**Figure 1: Fluorescence spectra of A) CdTe and B) CdTeSn(5%) quantum dots prepared at different reaction times**

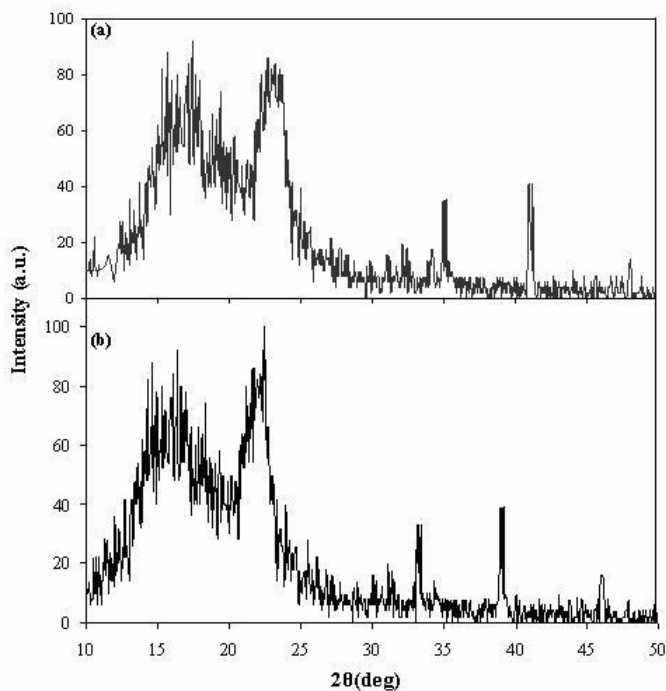


**Figure 2: Absorbance of A) CdTe and B) CdTeSn(5%) quantum dots prepared at different reaction times**

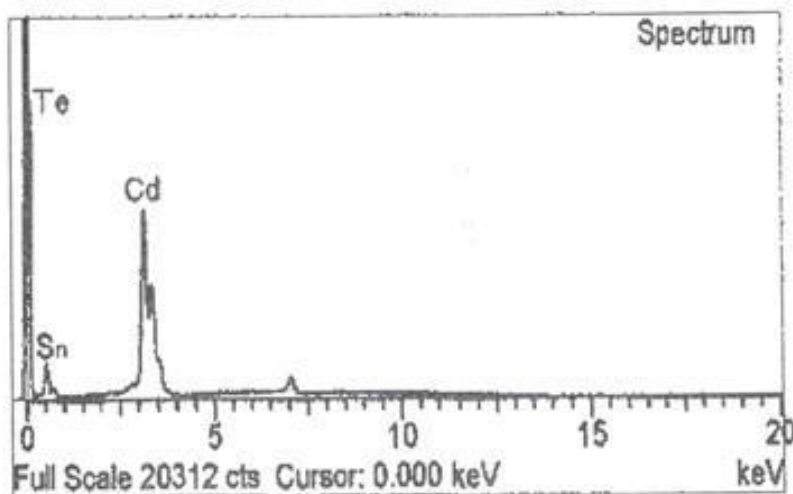
**Structural Characterization of CdTeSn(5%) Quantum Dots** Figure 3 shows TEM and SEM, Figure 4 shows typical XRD patterns obtained from powdered precipitated fractions of CdTeSn(5%) quantum dots synthesized when the stabilizer is TGA. Four distinct diffraction peaks were observed values of  $24.0^\circ$ ,  $34.0^\circ$ ,  $39.2^\circ$  and  $46.3^\circ$  respectively, corresponding to the (111), (220), (311) and (400) crystalline planes respectively of cubic CdTeSn(5%) structure.



**Figure 3: TEM and SEM pattern of the CdTeSn(5%) quantum dots**



**Figure 4: XRD patterns of the a) CdTeSn(5%) and b) CdTe quantum dots**



**Figure 5: EDAX patterns of the CdTeSn(5%)**

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**Table 1: Band Gap (E) and Size(D) of CdTeSn(5%) and CdTe quantum dots compared at different reaction times**

T(min)	D(nm)	E(ev)	$\lambda_{em}$ (nm)
<b>CdSnTe</b>			
30	3.99	1.97	651
90	4.32	1.91	670
150	4.60	1.88	682
210	5.36	1.81	702
270	6.42	1.75	731
<b>CdTe</b>			
30	2.92	2.36	526
90	2.14	2.29	541
150	3.30	2.23	556
210	3.50	2.14	580
270	3.67	2.07	601

**Conclusion**

Water-soluble CdTeSn(5%) Quantum dots have been reported in this paper. The additional Fig. 1 Fluorescence spectra of CdTeSn(5%) quantum dots prepared at different reaction times functional groups of the thiol capping molecules of the quantum dots provide their water solubility. The method reported here is also very attractive for its simplicity compared to other methods for producing water-soluble semiconductor Quantum dots. It also yields water-soluble Quantum dots with photophysical properties superior to those presented by Quantum dots prepared directly in water.

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