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Research Article

SYNTHESIS OF CdHgTe QUANTUM DOTS

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ABSTRACT

The comparison of growth processes and fluorescent properties of CdHgTe semiconductor quantum dots that are synthesized in different concentrations of Hg^{2+} in water are discussed in this paper. The samples are characterized through absorbtion (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. Under the best reaction conditions, the highest quantum yield can be attained by using thioglycollic acid (TGA) as modifier when the reaction time is 300 min.

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).

Characterization

Transition emission microscopy (TEM), and Asorbtions (UV) and Photoluminescence (PL) measurements were performed at room temperature.

Synthesis CdHgTe Quantum Dots

In a typical synthesis 2.5 mmol of $CdCl_2$, $2.5H_2O$ and 5, 10.15 weight percent of Hg^{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 $NaBH_4$ in 8 mL water and stirring then cooling in an icebath for 10 min) is passed through the solution together for 20 min. CdHgTe precursors are formed at this stage. The precursors are converted to CdHgTe quantum dots by refluxing the reaction mixture at 95ºC under helium-gas conditions.

RESULTS AND DISCUSSION

Optical Properties of CdHgTe Quantum Dots

Figure 1, 2, 3 shows photoluminescence (PL) spectra and absorbtions (UV) of a size series of CdHgTe quantum dots. The spectra were measured on as-prepared CdHgTe 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 CdHgTe Quantum dots appears which shifts to longer wavelengths as the particles grow in the reaction process. The size of the growing CdHgTe Quantum dots is 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 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.

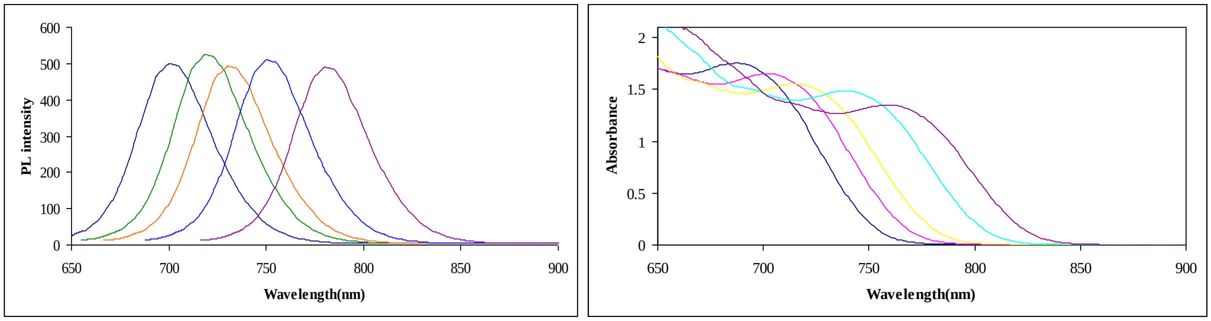

Figure 1: Fluorescence spectra and absorbtions of CdHgTe(5%) quantum dots prepared at different reaction times

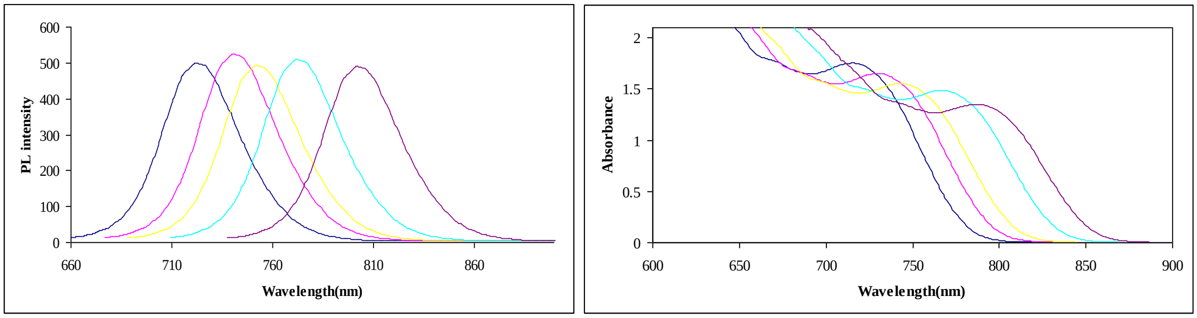

Figure 2: Fluorescence spectra and absorbtions of CdHgTe(10%) quantum dots prepared at different reaction times

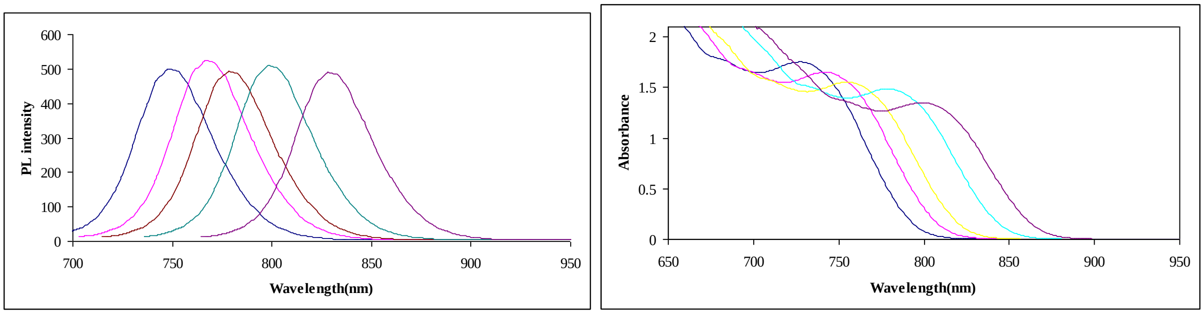

Figure 3: Fluorescence spectra and absorbtions of CdHgTe(15%) quantum dots prepared at different reaction times

Structural Characterization of CdHgTe Quantum Dots

Figure 4 shows TEM and typical XRD patterns obtained from powdered precipitated fractions of CdHgTe quantum dots synthesized when the stabilizer is TGA. Five distinct diffraction peaks were observed values of 24.0^{o}, 39.2^{o}, 46.3^{o} and 56.8^{o} respectively, corresponding to the (111), (220), (311) and (400) crystalline planes.

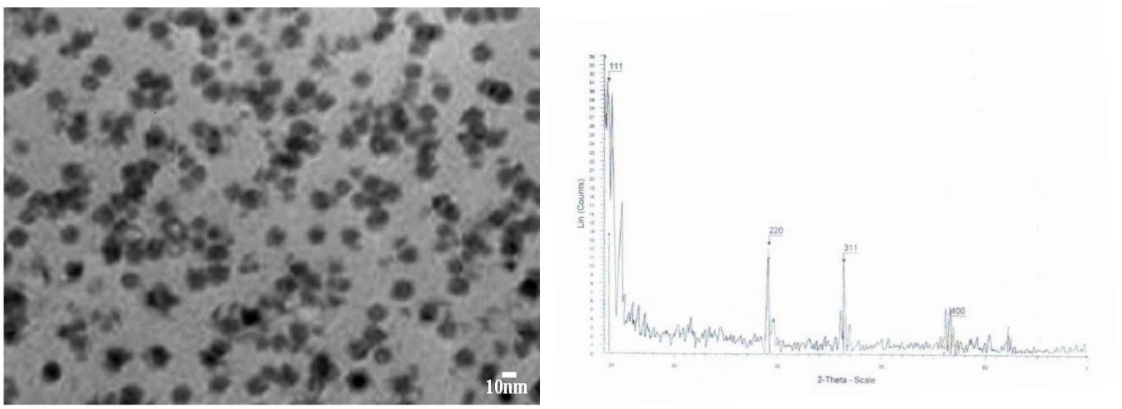

Figure 4: TEM and XRD pattern of the CdHgTe(5%) quantum dots

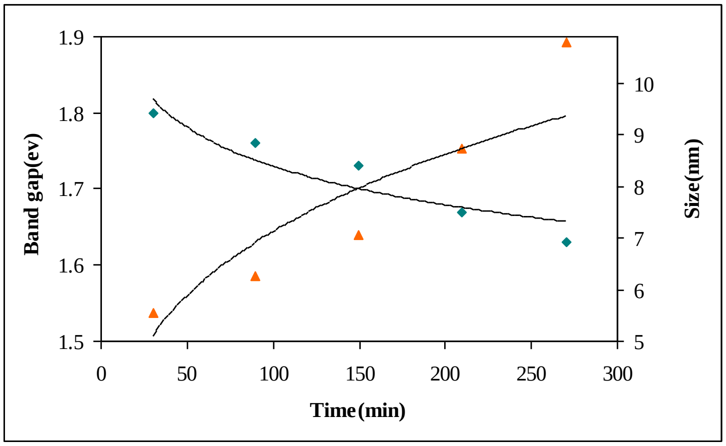

Figure 5: Band Gap and Size of CdHgTe quantum dots compared at different reaction times

Conclusion

Water-soluble CdHgTe Quantum dots have been reported in this paper. The additional Figure 1,2,3 Fluorescence spectra of CdHgTe 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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REFERENCES

Alivisatos AP (1996). Synchrotron based XRD study on nano crystalline SnO_2 under pressure. *Journal of Physics Chemistry* **100**(31) 13226–13239.

Bruchez M, Moronne M, Gin P, Weiss S and Alivisatos AP (1998). Semiconductor quantum dots as fluorescent biological. *Science* **281**(5385) 2013–2 016.

Brus L (1986). Luminescence Photophysics in Semiconductor Quantum dots. *Journal of Physics Chemistry* **90**(12) 2555–2560.

Chan W and Nie S (1998). Quantum Dot Bioconjugates for Ultrasensitive Nonisotopic Detection. *Science* **281**(5385) 2016–2018.

Colvin VL, Schlamp MC and Alivisatos AP (1994). Light-emitting dlodes made from cadmium selenlde quantum dots and a semiconducting polymer. *Nature* **370** 354–357.

Klimov VI, Mikhailovsky AA, Xu S, Malko A, Hollingsworth JA, Leatherdale CA, Eisler HJ and Bawendi MG (2000). Optical gain and stimulated emission in nanocrystal quantum dots. *Science* **290**(5490) 314–317.

Meng L and Song ZX (2004). Study of quantum size effects and optical characteristics in colloidal CdSnTe quantum dotes. *Biochemistry and Biophysics Development* **31**(2) 185–187.

Santra S, Yang H, Holloway PH, Stanley JT and Mericle RA (2005). Synthesis of Water-Dispersible Fluorescent, Radio-Opaque, and Paramagnetic CdS:Mn/ZnS Quantum Dots. *Journal of American Chemical Society* **127**(6) 1656–1657.