



Compare the types of quantum particles ZnSe

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Abstract

The effect of additives on the fluorescence spectra of semiconductor nanoparticles was studied using ZnSe particles of various sizes and composition. Based on the fluorescence quenching of quantum dots caused by material a simple, sensitive and rapid method was developed. In the end satisfactory results were obtained. The different synthesis methods was also discussed.

Keywords: synthesis, Quantum Dot, Nanoparticles ZnSe



Introduction

The use of quantum dots (QDs) for the development of sensors is one of the most developing fields of nanotechnology so far. Their fluorescence efficiency is sensitive to different compounds on their surface. (Gema et al, 2015). Luminescent semiconductor nanoparticles, commonly referred to as 'quantum dots' (QD), have had a profound impact on research in biological sensing, medical diagnostics and therapeutics. The focus has evolved from QDs as passive sensing or imaging agents to exploration of their use as therapeutic agents in the treatment of disease, or as multifunctional platforms capable of simultaneous diagnostic and therapeutic modalities (theranostics) (Aravind et al, 2013). Quantum confinement effects are responsible for such remarkable properties, which depend on their size and composition. Such effects offer the analyst high fluorescent quantum yields, narrow and symmetric size tuneable emission spectra, high resistance to photobleaching and long fluorescence lifetimes; features which can be highly useful for analytical purposes (Gema et al, 2013, Jie et al, 2014).

ZnSe is a wide band gap semiconductor material with bulk band gap of 2.7 eV at room temperature. It emits and absorbs from the blue to the ultra violet range due to the quantum confinement effect that occurs when the particle size becomes smaller than the exciton Bohr radius, so, these novel properties can be controlled by changing the particle size. (Hernández et al, 2014)

The synthesis of QDs can be divided into two categories: organic phase high temperature decomposition and aqueous phase synthesis. The organic phase high temperature synthesis can get nanoparticles with wide wavelengths, evenly dispersed, narrow particle size and high fluorescent intensity but poor water-soluble and serious flicker. The aqueous phase synthesis has been a hotspot for the obtained water-soluble QDs can be directly applied in the biological field. Compared with the organic phase high temperature synthesis the fluorescence intensity of aqueous phase synthesis QDs is lower, but they have the obvious advantages of simple operation, controllable surface charge, stronger anti photobleaching ability, better optical properties and others. And along with the synthesis methods improved, the fluorescence intensity of aqueous phase synthesis QDs is enhanced greatly (Jianqiu et al, 2015, Jing, 2015).

Recently, fluorescence resonance energy transfer (FRET) has been widely implemented in biosensors (Hong and Jong 2015). Fluorescence spectroscopy is a type of electromagnetic spectroscopy which analyzes fluorescence from a sample. It involves using a beam of light, usually ultraviolet light that excites the electrons in molecules of certain compounds and causes them to emit light; typically, but not necessarily, visible light. A complementary technique is absorption spectroscopy.

Synthesis of starch-capped ZnSe nanoparticles

In a typical room temperature reaction, an aqueous solution of 0.4 grams of ZnCl₂ was added to an aqueous solution of soluble starch (0.08 wt%) in a 100 mL one-necked round bottom flask, under constant stirring. The pH of the solution was adjusted from 6 to 11 using 0.1 M of ammonia solution. This was followed by a slow addition of 16*10⁻³ M of colourless selenide ion stock solution prepared by reduction of 0.025 g of selenium powder in deionised water using sodium borohydride. The colour of the solution changed immediately upon addition of selenide ion solution, indicating the formation of ZnSe nanoparticles. The mixture was further stirred for 5 h and aged for 24 h followed by filtration. The precipitate was washed several times and dried at room temperature to give a material which readily disperses in water. (K. Senthilkumar et al, 2012)

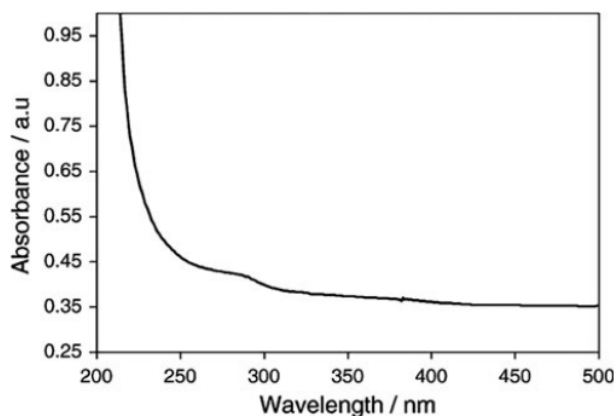


Fig. 3 UV-vis absorption spectra of starch-capped ZnSe nanoparticles

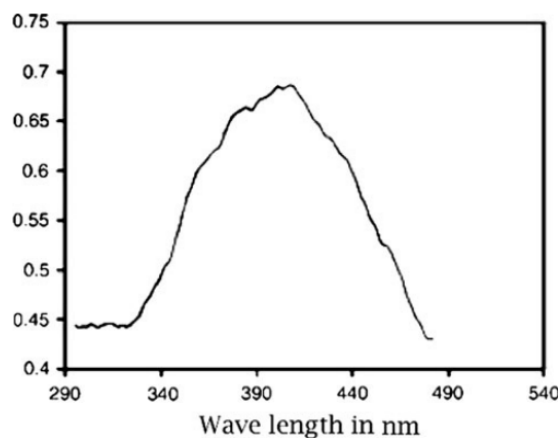


Fig. 4 Photo luminescence spectra of ZnSe nanoparticles

Synthesis of ZnSe

All the reagents were of analytical grade and used as received. Solution of zinc acetate ($(\text{CH}_3\text{COO})_2\text{Zn}\cdot 2\text{H}_2\text{O}$) (2.2 mM) prepared in 50 ml N, N dimethyl formamide (DMF) was stirred in ambient atmosphere for 15 minutes. Capping agent, thioglycerol ($\text{HSCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$), was added to the above solution and then solution of sodium selenite ($\text{Na}_2\text{SeO}_3\cdot 5\text{H}_2\text{O}$) (0.2 mM) prepared in 8 ml of distilled water was added dropwise. The resulting solution is stirred for 30 min and then further refluxed for 3 hours at 80 °C. The refluxed solution was concentrated using a rotary evaporator under vacuum and the particles were extracted by precipitation with the addition of iso-propanol to the concentrated solution. The precipitate was washed with methanol and then vacuum dried. The extracted powders were found to dissolve readily in DMF. The size of the particles varies inversely with the concentration of thioglycerol. In the present case, the concentration of thioglycerol was 0.1 ml (Sample A) and 0.3 ml (Sample B) in order to obtain two different sizes. (Aparna et al, 2008)

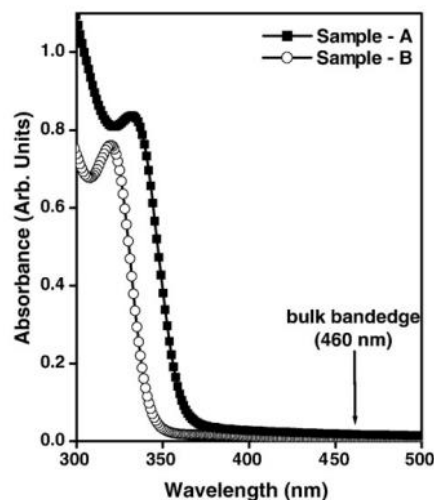


Fig. 3. UV-Vis absorption spectra for ZnSe nanoparticles

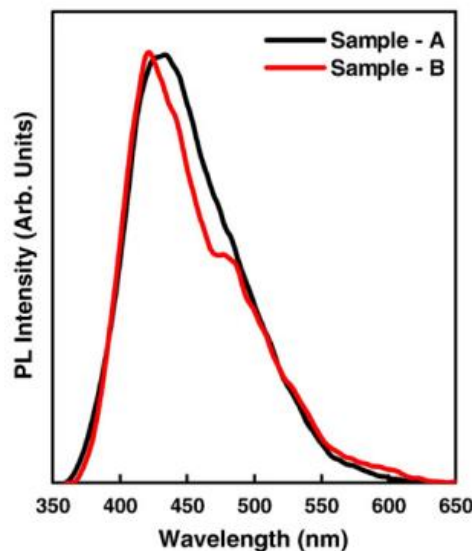


Fig. 4. Luminescence spectra for ZnSe nanoparticles

Preparation of ZnSe NPs

All chemicals were of analytical grade and used as received, without further purification. The synthesis of the ZnSe precursor was carried out using the following procedures: $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (0.5 mmol) was dissolved in 30 ml of EDTA solution. The selenium powder (99.95%) (0.5 mmol) was dissolved in 30 ml of NaOH solution. After stirring for 1 h, both were added into one beaker. Then after stirring for a further hour, the mixed solution was transferred into the 80-ml Teflon-lined autoclave. The autoclaves were sealed and heated at 180°C for 10 h (Sample C), 20 h (Sample B) and 30 h (Sample A), respectively. After the reaction, the autoclaves were cooled to the room temperature. The products were washed with ethanol and deionized water several times and then separated by centrifugation. They were then dried at 60°C for 1 h to obtain the precursors. Finally, the precursors were annealed at 300°C for 2 h to get the yellow ZnSe samples. (Bo Feng et al, 2014)

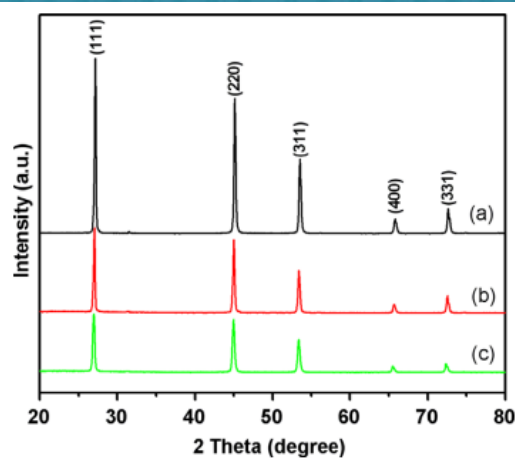


Fig. 1. XRD patterns of ZnSe NPs, Sample A (a), Sample B (b), and Sample C (c)

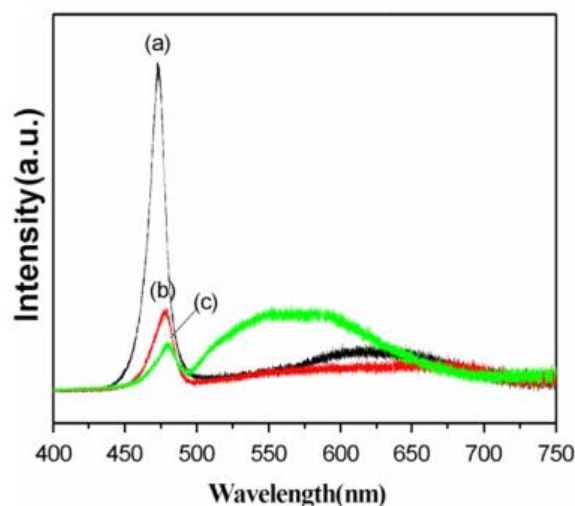


Fig. 3.(A) PL spectrum of ZnSe NPs with different particle sizes, Sample A (a), Sample B (b) and Sample C (c)

Conclusion

In conclusion, we have synthesized a series of paramagnetic and luminescent nanoparticles with high quantum yield and relaxivity and simple, rapid and sensitive method for material analysis has been established based on the fluorescence intensity quenching of ZnSe QDs.

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