Synthesis of CdSe Quantum dots in organic and aqueous solution

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Introduction

Quantum dots (QDs) are semiconducting nanocrystals with unique properties that offer opportunities to a wide array of sectors. This could be in cancer research or even in the manufacturing of new LED technology. If the QDs are excited, they will emit light within the visible light spectrum. This study tries to investigate the optical properties of CdSe QDs that are synthesized in different growth solutions and with the use of different stabilizing agents.
There are three types of syntheses that we carried out. QDs were synthesized in organic solution with and without the addition of oleylamine (stabilizing agent). The last synthesis was performed in aqueous solution with the addition of thiol shelling.

Materials and methods

It is important to note that a lot of the used chemicals are very toxic, and precautions should be taken.

The hot injection method was used to synthesize the CdSe QDs in organic solution. The cadmium and selenium precursors were formed individually and then brought together in a heated growth solution. In the later synthesis oleylamine was added to stabilize the formed crystals. Fractions were taken at specific times.

The synthesis in aqueous solution is very similar. The precursors were formed and added together while getting stirred and heated. Here a reflux was needed since water is more volatile than the organic solvent.

Results and discussion

Organic synthesis without oleylamine

The CdSe QDs were synthesized and emitted peak wavelengths between 465 and 555nm. This is dependent on how long the reaction takes place. If the reaction is stopped early, the formed QDs are still very small and emit light with low wavelengths. If they have time to grow, the band gap gets smaller, and the peak emission wavelength rises. The intensity of the emitted light rises in time till Oswald ripening takes place. This is a process where bigger particles are favoured, and the smaller ones get deposited on the big ones. When this happens, the intensity drops because there are less particles present. These processes are present in all the carried-out experiments.

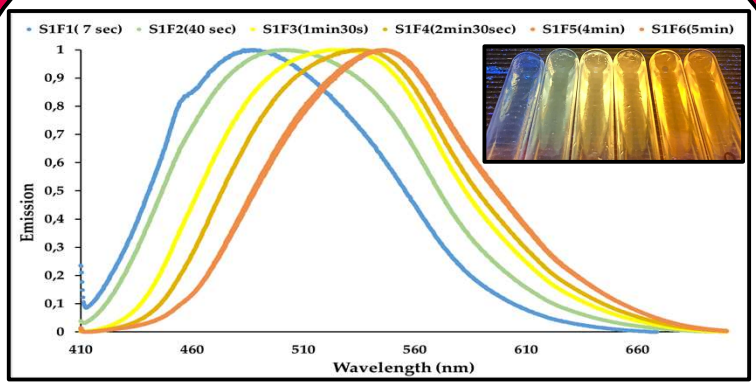
Organic synthesis with oleylamine

With oleylamine present, the intensity of the QDs was much higher and it was possible to reach emission peak wavelengths of 587nm. There also originates another base peak. This is due to the formation of clusters between the QDs and the oleylamine. The peaks also are much narrower which means the colours are purer. This synthesis is much more favourable than the one without oleylamine.

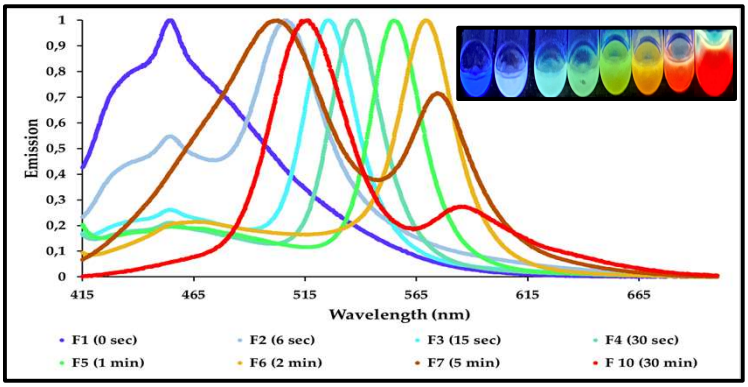
Aqueous synthesis

Working in aqueous solution is sometimes preferred. For example, if the QDs have to be biocompatible. QDs will usually fall apart in aqueous solution or have poor optical properties but not if you can get a shelling around them. If a large excess of thiols is added, they will form a protecting barrier around the QDs. Different thiols could be added to get other peak wavelengths. This is very advantageous because that way you aren't bound to the reaction times as much and this makes it more reproduceable.

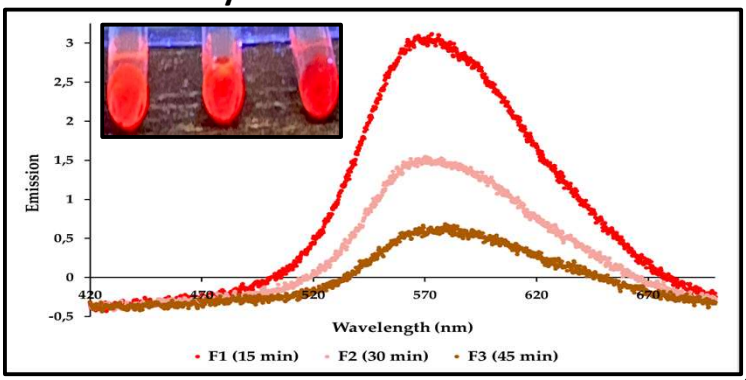
Synthesis in organic medium



Synthesis in organic medium with oleylamine



Synthesis in water solution



Conclusion

We managed to synthesise CdSe QDs using three different approaches. Each approach delivered interesting results that were accordingly studied and interpreted by spectrophotometric analysis. Although organic synthesis without oleylamine was successful in making QDs that emit colours from blue to orange. The addition of oleylamine is necessary to improve the optical properties of CdSe QDs. The synthesis in aqueous solution was successful as well but the obtained CdSe QDs suffered in terms of their intensity because of the applied thiol shelling.

Reference

Matthew L. Landry,† Thomas E. Morrell, Theodora K. Karagounis,† Chih-Hao Hsia, and Chia-Ying Wang. Simple Syntheses of CdSe Quantum Dots. J. Chem. Educ. 31/12/2013 ; 91 ;274-279

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