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Synthesis, optical and structural characterization of fluorescent water soluble CdSe/CdS quantum dots

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Abstract – Hydrophilic highly fluorescent CdSe/CdS core-shell quantum dots were prepared via colloidal synthesis in aqueous medium, physiological pH and room temperature. Optical and structural characterizations were performed by absorption, emission and excitation spectroscopy, XRD and TEM. The resulting quantum dots are highly fluorescent and photostable.

Colloidal fluorescent semiconductor nanoparticles in quantum confinement regimen, also named quantum dots (QDs) are mostly prepared by synthesis in organic media, such as trioctylphosphine and trioctylphosphine oxide (TOP/TOPO) [1]. In this study we present and discuss the results we obtained by using simple synthesis route we developed. With this simple route, highly fluorescent CdSe/CdS core-shell QDs, were obtained in aqueous medium and physiological pH at room temperature. These water soluble QDs were synthesized as follows: mercapto acetic acid (MAA) was added to a solution of $Cd(NO_3)_2$ in ultra-pure water medium in a proportion of 1:2. In a separate flask, selenide ions (Se^{2-}) were obtained by reducing metallic selenium (Se^0) with sodium borohydret in alkaline medium, under argon atmosphere. The solution of $Cd(NO_3)_2$ with MAA was added to the reduced selenide containing solution, under vigorous agitation. Nanocrystals of cadmium selenide (CdSe) are formed and further capped with cadmium sulfide (CdS) layer, which corresponds to the passivation shell. MAA is the font of the sulfide ions (S^{2-}) which allow the formation of the CdS shell. At the end of the synthesis, the colloidal suspension pH was adjusted to 7.0, by slow addition of 0.5M sodium hydroxide solution (NaOH). Optical characterization of the samples was performed by spectroscopic measurements. Figure 1 shows absorption, excitation and emission spectra. Figure 2 shows a CdSe/CdS QDs containing solution under excitation by UV lamp (excitation wavelength = 365 nm). X-ray diffractometry (XRD) and transmission electronic microscopy (TEM) measurements were performed in order to obtain structural data of the samples. QD's average size, average diameter, size dispersion and surface properties may be directly obtained or even inferred from these results.

By using simple experimental and low coast procedures, high quality hydrophilic CdSe/CdS QDs were obtained in physiological pH. These QDs are ready to be used in biological applications, such as biolabelling and histopathologic protocols.

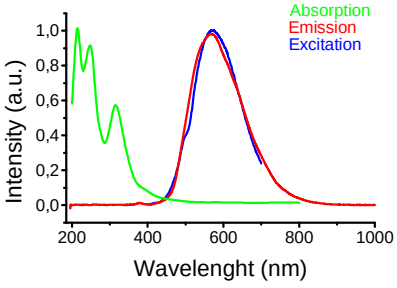

Figure 1: CdSe/CdS QDs absorption, emission and excitation spectra.

Figure 2: Fluorescent CdSe/CdS core-shell quantum dots in aqueous medium. (Excitation wavelength = 365nm).

References

[1] Xin Ai, Qi Xu, Marcus Jones, Qing Song, Shi-you Ding, Randy J. Ellingson, Mike Himmel and Garry Rumbles, Photochem. Photobiol. Sci., 2007, 6, 1027–1033.