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# Preparation and Characterization of Water-Soluble Semiconductor Quantum Dots (QDs) for Bioconjugation

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# Preparation and Characterization of Water-Soluble Semiconductor Quantum Dots (QDs) for Bioconjugation

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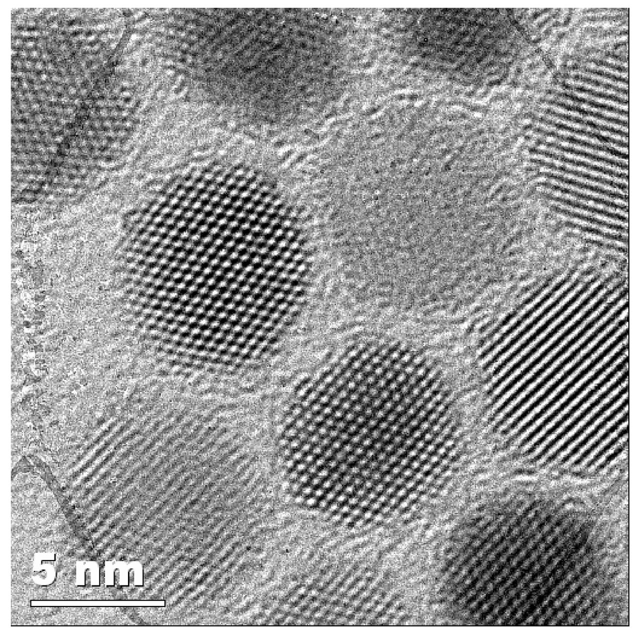
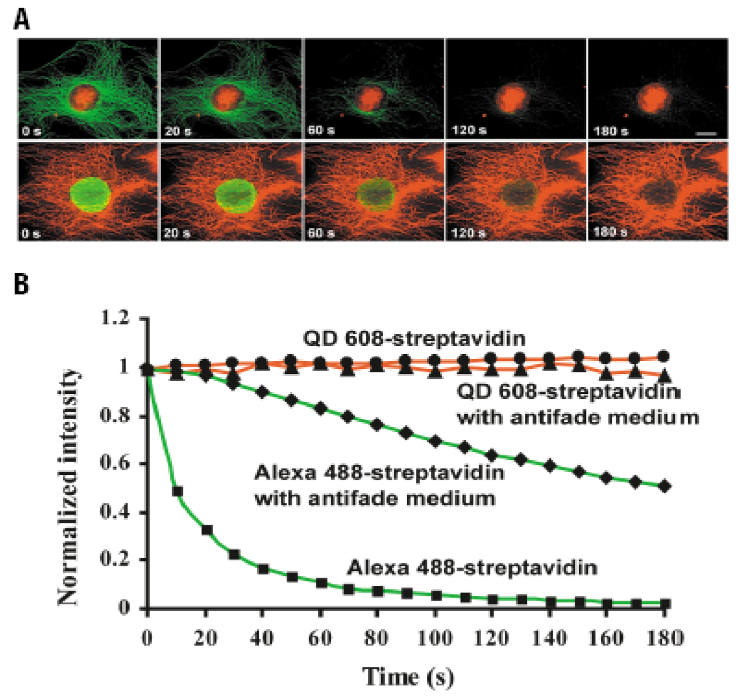
**Abstract:**
Semiconductor nanocrystals, or quantum dots (QDs), exhibit unique size-dependent optical properties. Absorption and emission peaks of QDs shift to longer wavelengths as their sizes increase due to the quantum confinement effect. Quantum dots are suitable for biological applications due to their high fluorescence quantum yield and resistance to photo-bleaching. CdSe QD cores were synthesized by thermal pyrolysis of Cd and Se precursors in the organic solvent octadecene. To increase the fluorescence quantum yield and the stability of QDs, a CdS shell was grown by alternate additions of Cd and S precursors. To render the QDs soluble in water and to use them in biological applications, 3-mercaptopropionic acid was used. Absorption and fluorescence of the QDs were measured to understand the relation between the surface structure and optical properties.

## Background:

Semiconductor nanocrystals, or quantum dots (QDs), show unique optical properties that are not observed in bulk materials. Their absorption and fluorescence wavelength change as the particle size changes. In addition to such interesting properties, QDs exhibit high fluorescence quantum yield and resistance to photo-bleaching, which make them good candidates for biological imaging probes.



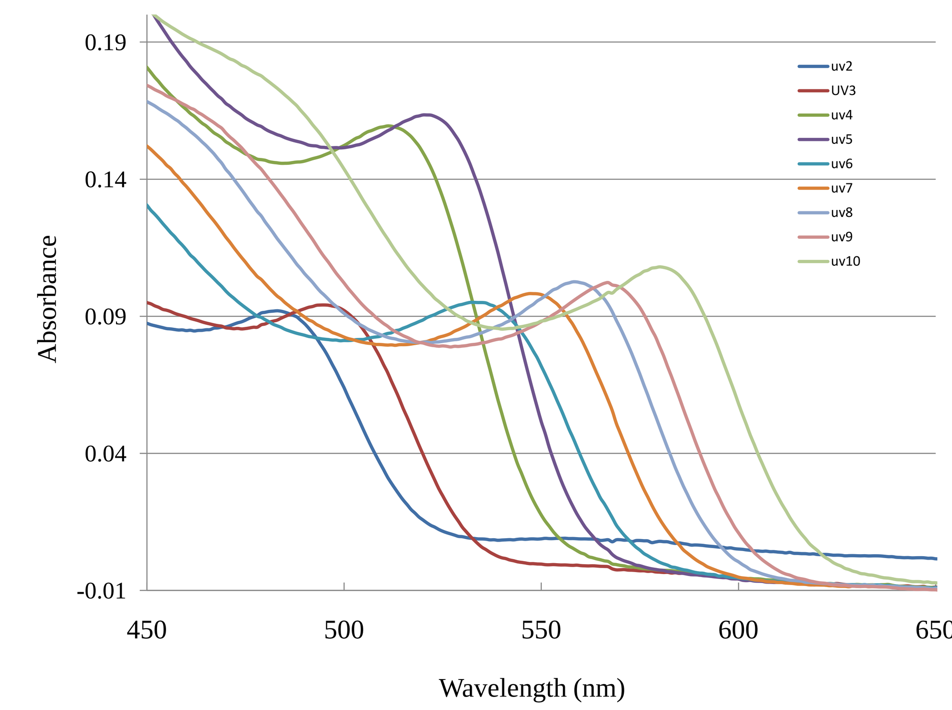

## Research Objectives:

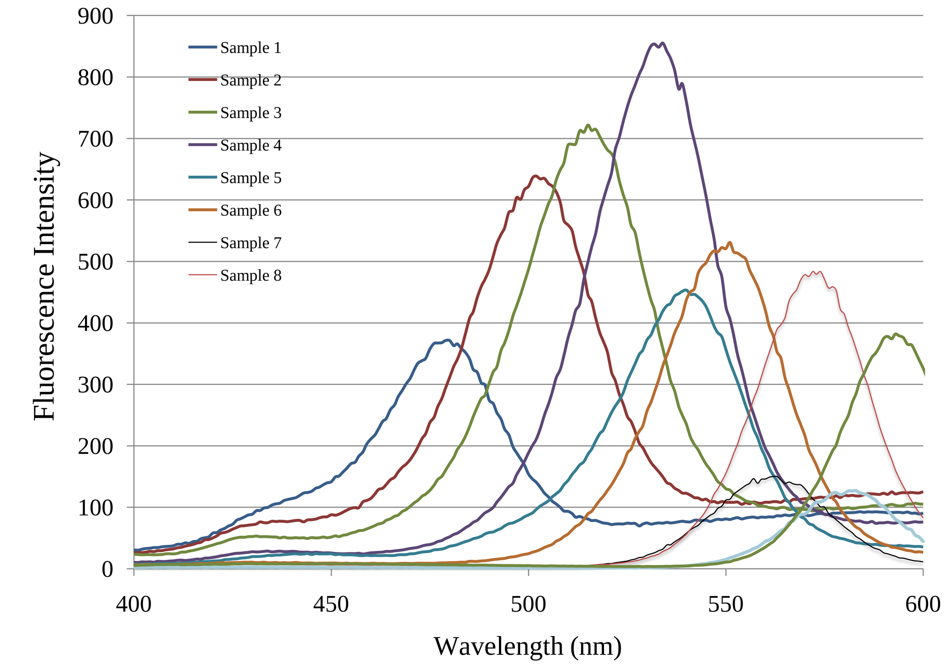
The goal of this research is to synthesize CdSe and CdSe/CdS (core/shell) QDs that show strong fluorescence and to functionalize their surfaces to render them water-soluble and biocompatible. To achieve these goals, we used colloidal chemistry techniques to prepare QDs, investigated their optical properties, and surface functionalized them with bi-functional ligands.

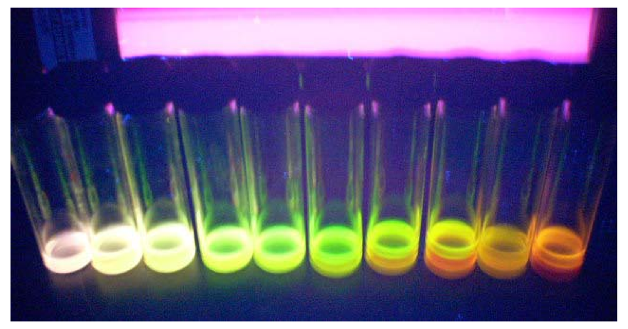
**References:**
(1) Li, J.J, Wang, A., Guo, W., Keay, J.C., Mishima, T.D., Johnson, M.B., and Peng, X. *Journal of the American Chemical Society, 2003, 125 (41)*, 12567-12575.
(2) Bruchez, M. *et. al., Nature Biotechnol, 2001, 21*, 41

## Synthesis of CdSe Quantum Dots:

Selenium (Se) dissolved in octadecene was rapidly injected into hot (180-230 ºC) CdO/octadecene solution, which caused sudden color change. QDs were grown until the desired size was achieved. The absorption spectra were measured to monitor the growth of QDs.



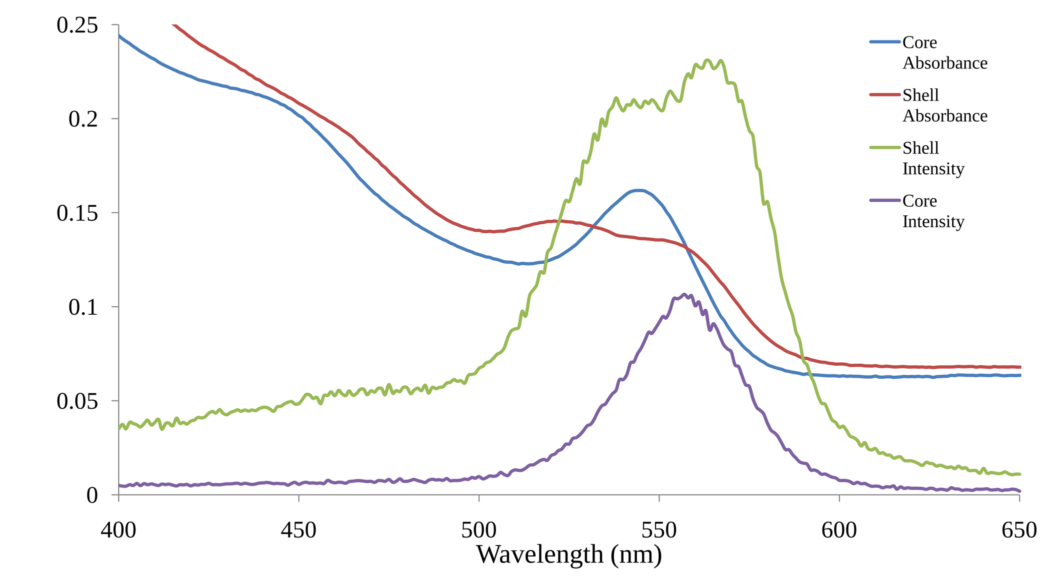



## Future Work:

DNA and Protein molecules will be attached to water-soluble QDs for further assembly with biological molecules and DNA nanostructures.

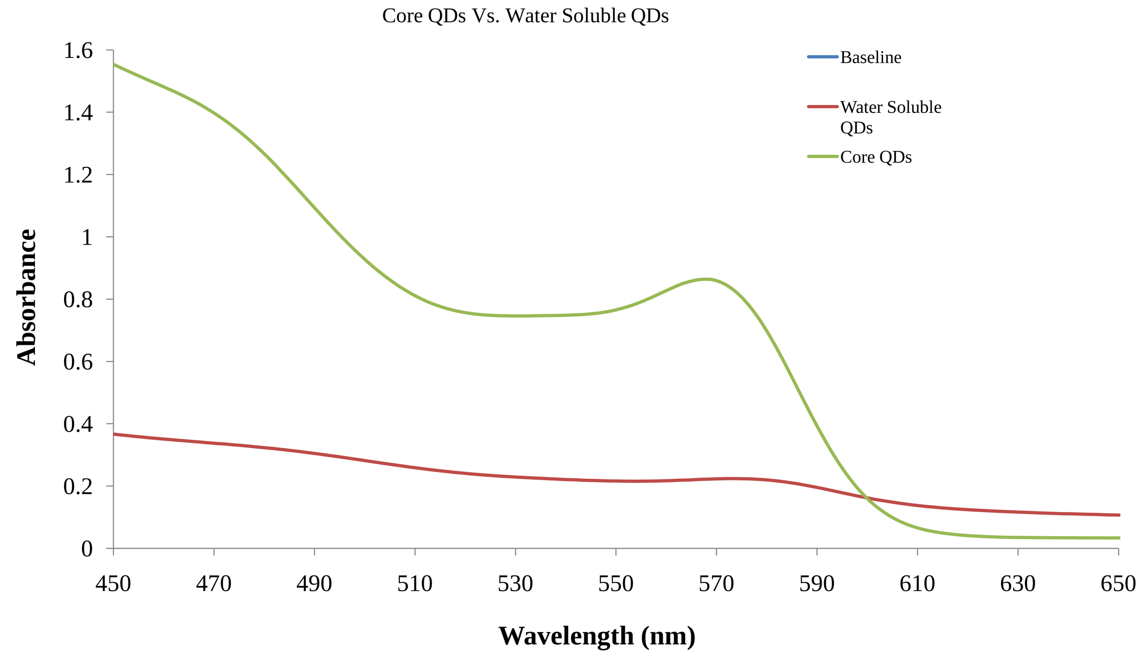
## Core/Shell Quantum Dots:

CdS shell was grown on CdSe QD surface to increase the fluorescence quantum yield. The shell growth was done by slowly adding a mixture of CdO and S to CdSe QD solution.
The comparison between the fluorescene spectra of core and core/shell QDs display the increase of the fluorescence.




## Water Soluble QDs:

To make the QDs soluble in water, 3-mercaptopropionic acid was used. The bifunctional ligand imparts water solubility to QDs by introducing polar groups on the surface. The absorption peak shifted slightly to a longer wavelength as a result of this reaction.

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