IMAGING THE INTERACTIONS BETWEEN QUANTUM DOTS AND LIPOSOMES USING SINGLE MOLECULE MICROSCOPY

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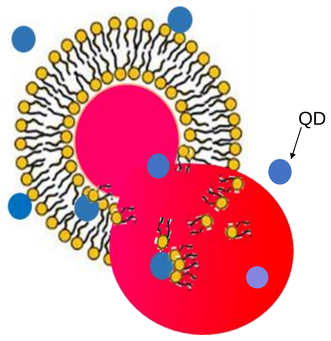
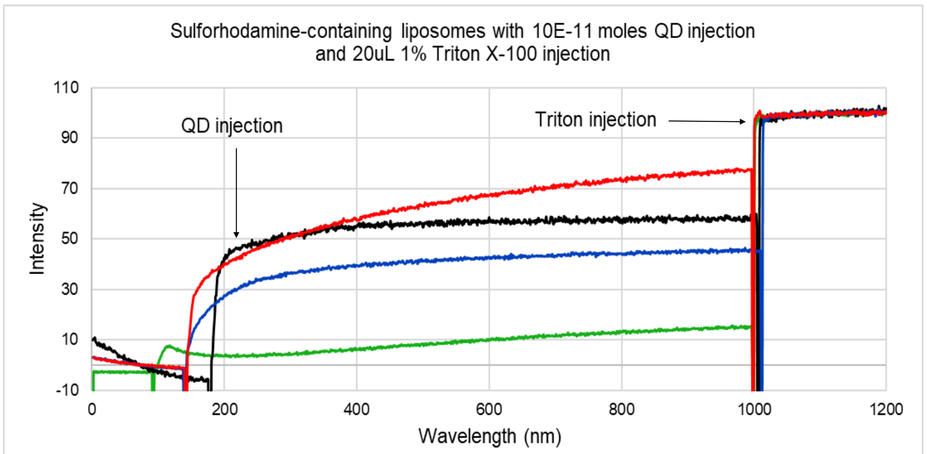
ABSTRACT

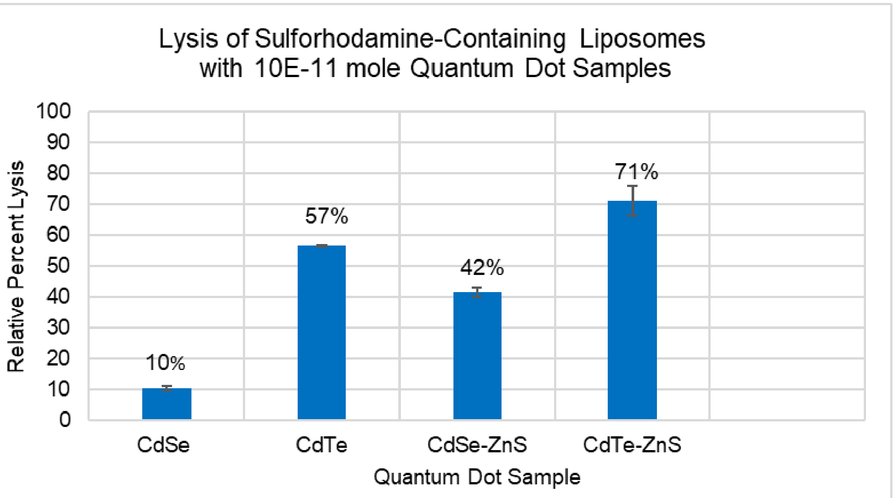
Semiconductor Quantum dots (QD) are luminescent nanocrystals ranging from two to ten nanometers in diameter. Their optical properties are especially useful for medical imaging and in commercial electronic devices. The wide spread use of luminescent QD has raised significant health and environmental concerns since luminescent QD are often composed of toxic chemicals- such as cadmium- which are known to damage living organisms. In addition, synthetic nanoparticles including QD exhibit complex toxicity mechanisms that are not fully understood. In our laboratory, we make use of fluorescent phospholipid vesicles (liposomes) as a model of bacterial cell membranes, to investigate the interactions of QD with bacteria at the molecular level. This summer I studied the interactions of water-dispersed CdSe, CdSe/ZnS, CdTe and CdTe/ZnS QD with liposomes using high resolution single molecule fluorescence microscopy. Our studies reveal that QD interactions with liposomes result in varying degrees of membrane damage but not in total rupture. Together with other complementary techniques including dynamic light scattering (DLS), transmission electron microscopy (TEM) and inductive coupled plasma mass spectrometry (ICPMS), our experiments support a model involving association of QD with the membranes and physical membrane damage due to the accumulation of QD on the membrane.



Sulforhodamine B-Containing Liposomes

SPECTROSCOPY RESULTS





QUANTUM DOT SYNTHESIS AND ANALYSIS

CdSe and CdSe/ZnS QD Synthesis

Injection of Trioctylphosphine (TOP) selenide precursor into CdAcAc precursor

CdTe and CdTe/ZnS QD Synthesis

Injection of Trioctylphosphine (TOP) telluride precursor into CdO precursor

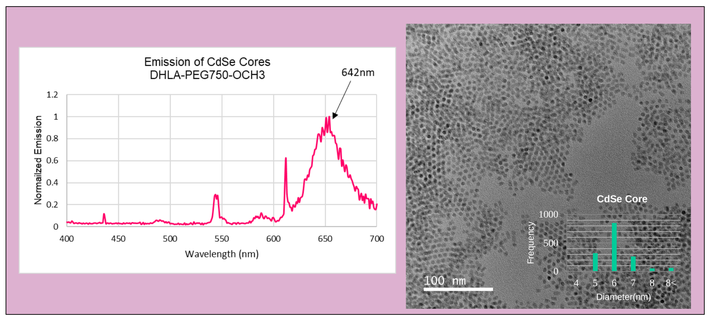
Purification through centrifugation

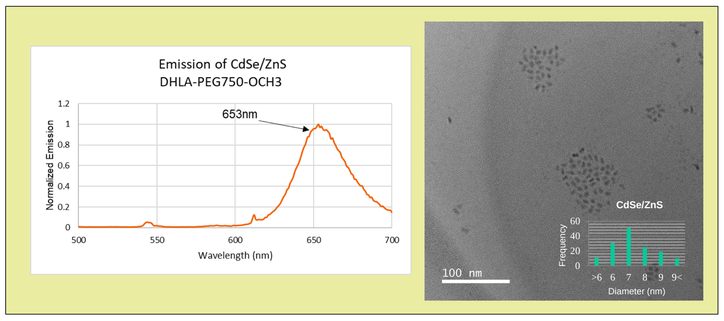
Shelling the QD

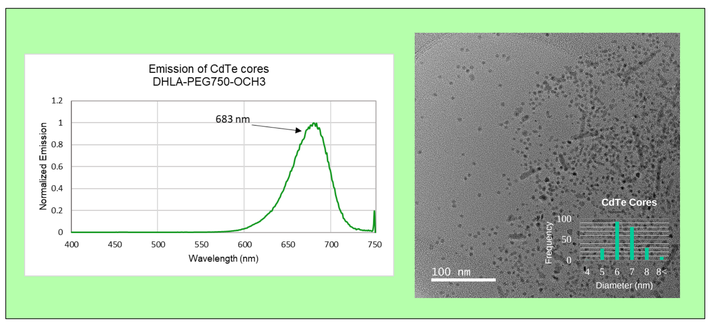
Successive Ionic Layer Adsorption and Reaction (SILAR) with Zinc-oleylamine and TOPSulfur

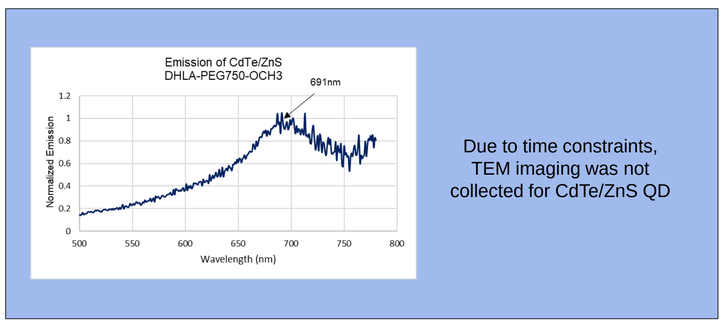
Cap Exchange

Cap exchanged with DHLA-PEG-OCH3 to form water-dispersed QD







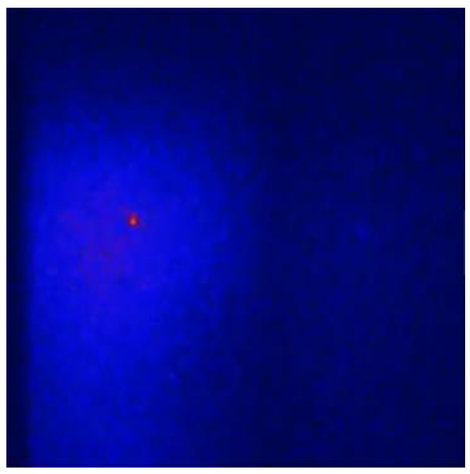


Due to time constraints, TEM imaging was not collected for CdTe/ZnS QD

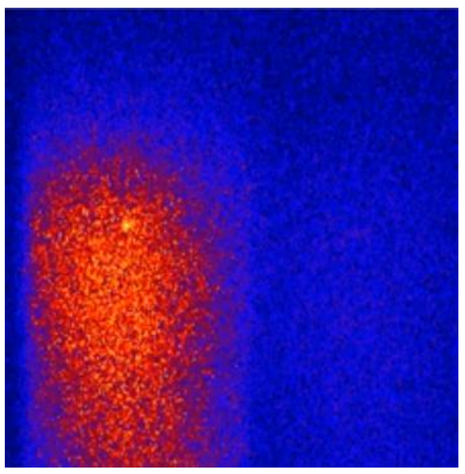
Emission Spectrum and TEM data collected for each type of quantum dot synthesized. **Pink** : CdSe cores, **Green**: CdTe cores, **Yellow**: CdSe/ZnS, and **Blue**: CdTe/ZnS

MICROSCOPY RESULTS

Before Injection



After Injection



Above images were obtained using high resolution single molecule fluorescence microscopy. 50mM rhodamine-containing liposomes were burst by injection of 20% Triton X-100 to display maximum lysis.

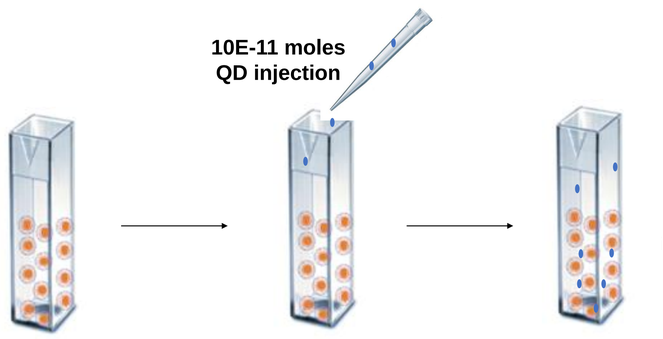
LIPOSOME SYNTHESIS AND ANALYSIS

Two types of liposomes containing sulforhodamine B dye were synthesized and purified for microscopy and lysis assays (demonstrated below)

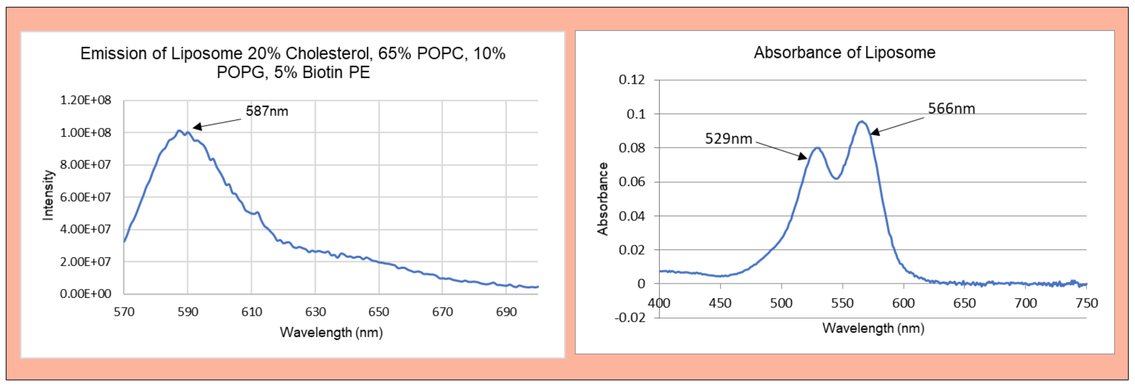
Liposome Composition

1) 20% cholesterol, 65% POPC, 10% POPG, 5% Biotin PE with 50mM sulforhodamine B dye.

2) 85% POPC, 10% POPG, 5% Biotin PE with 50mM sulforhodamine B dye



Quantum dot injection was followed by 1% Triton X-100 injection to ensure maximum lysis of the liposomes



CONCLUSIONS

Microscopy results are sensitive to variation in quantum dot and liposome composition, concentration, and purity. These components must be optimized to obtain valuable results. Concentration of the components of the liposome must be optimized to ensure the liposomes are strong enough to bind to the microscope plate after incubation but not so strong that they are difficult to lyse with the quantum dot samples. Additionally, it is important that the liposome sample is purified the day of microscopy to enhance imaging results. CdTe core quantum dots seem to lyse the liposomes most efficiently according to microscopy even though emission data shows them to be much less fluorescent than the CdSe cores. This may be due to the size variation as seen in the TEM images.

Future work will include further imaging using varying types of QD and liposomes to optimize imaging results and view the effects of QD surface alterations on the lysis rate of the liposomes. Additionally, TEM imaging of the CdTe/ZnS quantum dots will be done to check for size homogeneity.

ACKNOWLEDGEMENTS

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