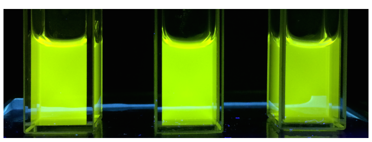
QUANTUM DOT CHEMICAL STABILITY AND THEIR INTERACTION WITH ZEBRAFISH EMBRYOS

Hyo W. Park[1, 3], Melissa Richardson[1], Richard Brown[1], April Laranang[1], Rachel Brewster[2], Zeev Rosenzweig[1]

National Science Foundation Division of Chemistry, The Center for Sustainable Nanotechnology (CSN)
[1]Department of Chemistry and Biochemistry, University of Maryland, Baltimore County, 21250
[2]Department of Biological Sciences, University of Maryland, Baltimore County, 21250
[3]Division of Natural Sciences and Mathematics, Chaminade University of Honolulu, 96816

Background

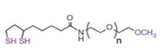
Semiconductor quantum dots (QD) are nanoparticles with optical and electronic properties. The nanometric dimensions of QD result in unique photophysical properties, which include high brightness in the visible range of the electromagnetic spectrum, high photostability, narrow emission peaks, and size dependent emission tunability. The unique photophysical properties of luminescent semiconductor QDs enable their use in biological imaging, labeling and detection, and as optical elements in consumer electronics, light emitting displays, and photovoltaic devices. Semiconductor QDs have been drawing wide spread interest, however it is known that QDs that contain heavy metals, such as cadmium, could be toxic in high concentrations. There is concern that the wide scale use will have adverse impacts on human health and the environment.



Materials and Methods

- Core Chemistry: **Cadmium selenide**
- Shell Chemistry: **Zinc sulfide**
- Surface Chemistry:

Pre-Cap Exchange:



Trioctylphosphine oxide (TOPO)

Post-Cap Exchange:

Dihydrolipoic acid- polyethylene glycol-methoxy (DHLA PEG-OCH_3)

- Colloidal stability of CdSe/ZnS/ DHLA(750MW)PEG-OCH_3 was analyzed through UV-VIS absorbance spectroscopy, steady-state fluorescence spectroscopy and florescence lifetime spectroscopy measurements over the course of a week.

Aim

To understand if the surface chemistry will alter the stability of luminescent quantum dots in biological solutions and if it can be used as a tool to regulate levels of nanotoxicity in zebrafish embryos.

Results and Analysis

The QD that are capped with DHLA(750MW)PEG-OCH_3 ligand show colloidal stability in all buffer solutions with the exception of minimal media, and pH levels of 4 & 5.

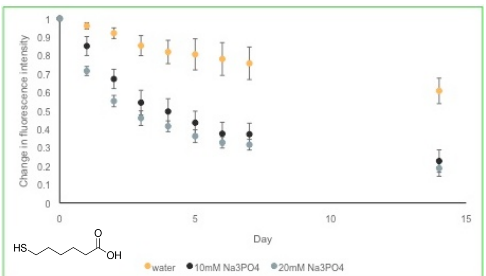


Figure 1. CdSe/ZnS/MUA QD in salt solutions over time

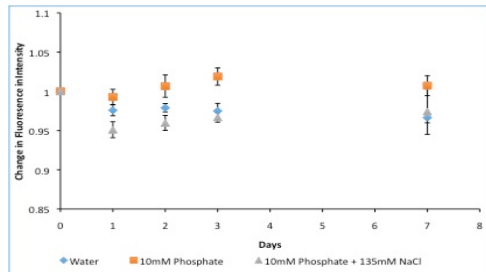


Figure 2. CdSe/ZnS/DHLA (750) PEG-OCH3 QD in salt solutions over time

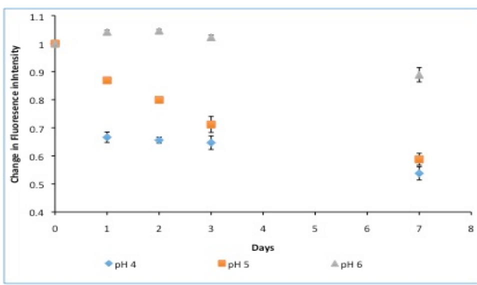


Figure 3. CdSe/ZnS/DHLA (750) PEG-OCH3 QD in various pH levels over time

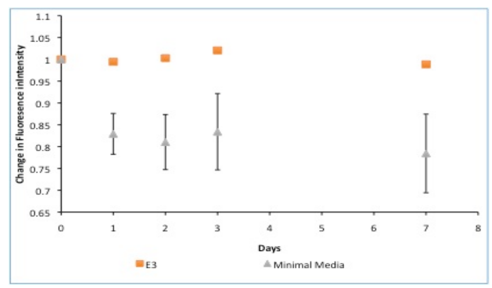


Figure 4. CdSe/ZnS/DHLA (750) PEG-OCH3 QD in various media over time

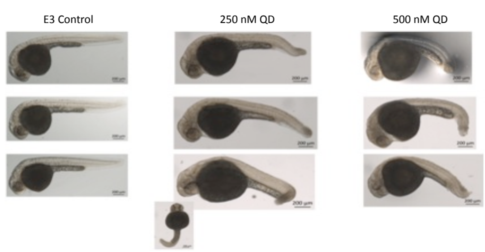


Figure 5. Brightfield Micrographs of 24hpf embryos exposed to CdSe/ZnS/DHLA (750) PEG-OCH3

Conclusions

- Altering the surface chemistry can affect the colloidal stability of QD in biological solutions.
- Cadmium based QD are still toxic regardless of surface chemistry.

Impact statement: Through this research, we understand the specific chemical and physical interactions between Cadmium based Quantum Dots and living organisms.

Future Direction

- Continue stability studies with charged ligands
- Use alternatives to cadmium based cores

Acknowledgements

- The project is supported by the Research Experience for Undergraduates and Undergraduate Veterans (REU/REV) Program of the National Science Foundation Center for Chemical Innovation on Sustainable Nanotechnology (CSN). This material is based upon work supported by the National Science Foundation under Grant No.CHE-1503408
- Brewster Lab, University of Maryland, Baltimore County
- The Office of Health Professions Advising and Undergraduate Research, Chaminade University of Honolulu

References

1. Lei, Y., Xiao, Q., Huang, S. et al. J Nanopart Res (2011) 13: 6895. doi:10.1007/s11051-011-0597-3.
2. Domingos, R.F., Franco, C. & Pinheiro, J.P. Environ Sci Pollut Res (2013) 20: 4872. doi:10.1007/s11356-012-1457-0

The Center for Sustainable Nanotechnology is a Center for Chemical Innovation, which is funded by the National Science Foundation under Grant No. CHE-1503408

The Center for Sustainable Nanotechnology

Pacific Northwest NATIONAL LABORATORY · TUSKEGEE UNIVERSITY · THE UNIVERSITY OF IOWA · UWM