Research Horizons Day
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COLLEGE OF SCIENCE
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Research Horizons Day

Scalable Cation Exchange Reactions of Metal Chalcogenide Quantum Dots

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Introduction

Quantum Dots (QDs) are semiconducting nanocrystals that exhibit properties such as size dependent emission wavelength and broad excitation range. QDs typically range from 2-10nm in diameter and show great promise in drug delivery, catalysis, solar cells and tv displays.

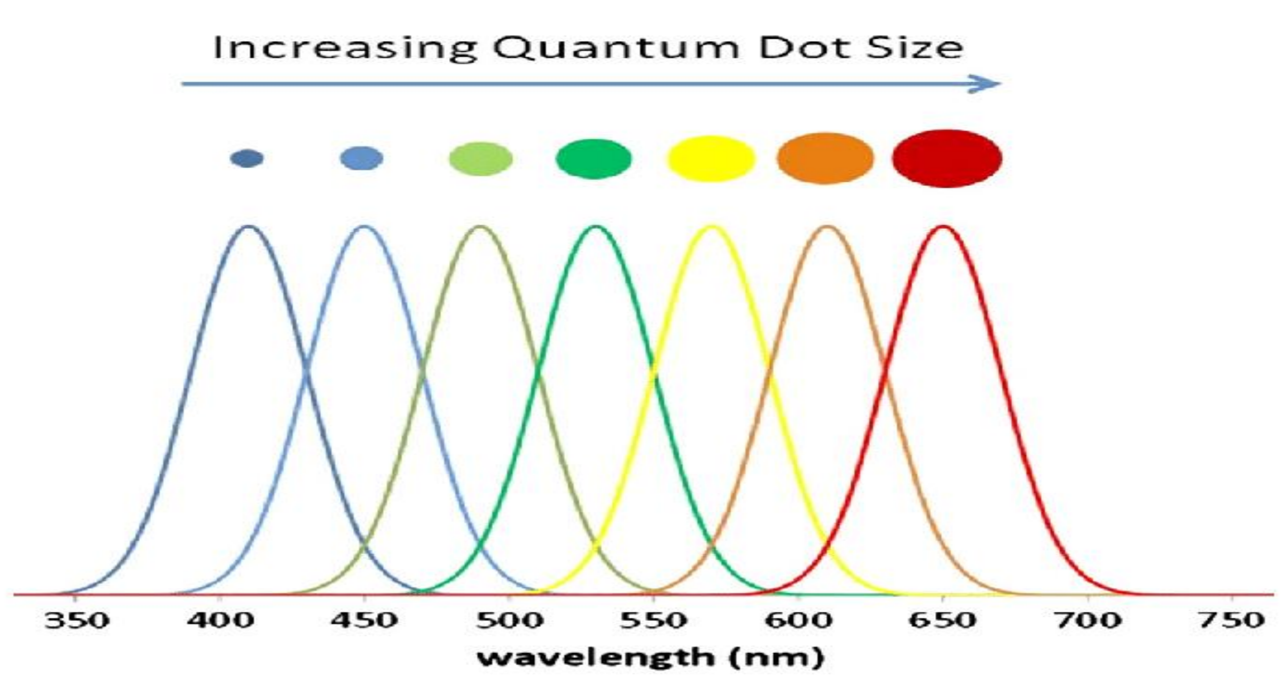

Figure 1: Fluorescence Emission Spectra displaying the size dependent properties of QDs.

Materials and Methods

1. CdS QDs were synthesized in large scale using methodology developed by Zhang et al.
2. Cd^{2+} and Ag^{+} reagents to perform cation exchange were synthesized using $AgNO_3$, Acetonitrile, Octylamine, Oleylamine and Toluene and stored in an incubator at 35 °C.
3. CE was performed by adding a 10:1 stoichiometric excess and purifying the QDs using 1:1:1 reaction mixture: 1-butanol: 1-methanol volume ratio and centrifuging at 17,000 x g.
4. The QDs were resuspended in the original solvent (hexanes).

Results

Rapid, scalable cation exchange (CE) was performed in semiconducting QDs. CdSe QDs were CE at room temperature to Ag_2Se and reverse CE back to CdSe to improve Quantum Yield. Optical, structural, chemical and microscopic characterization suggested that the reactions approached complete replacement of cations.

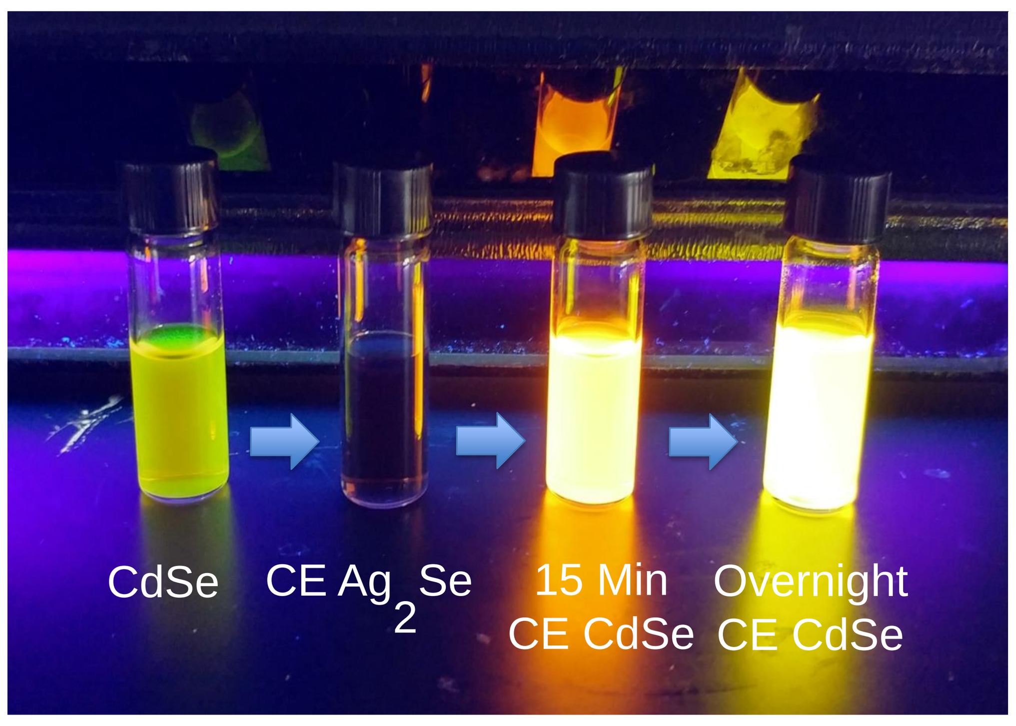

Figure 2: Original and CE QDs Fluorescence under UV Light.

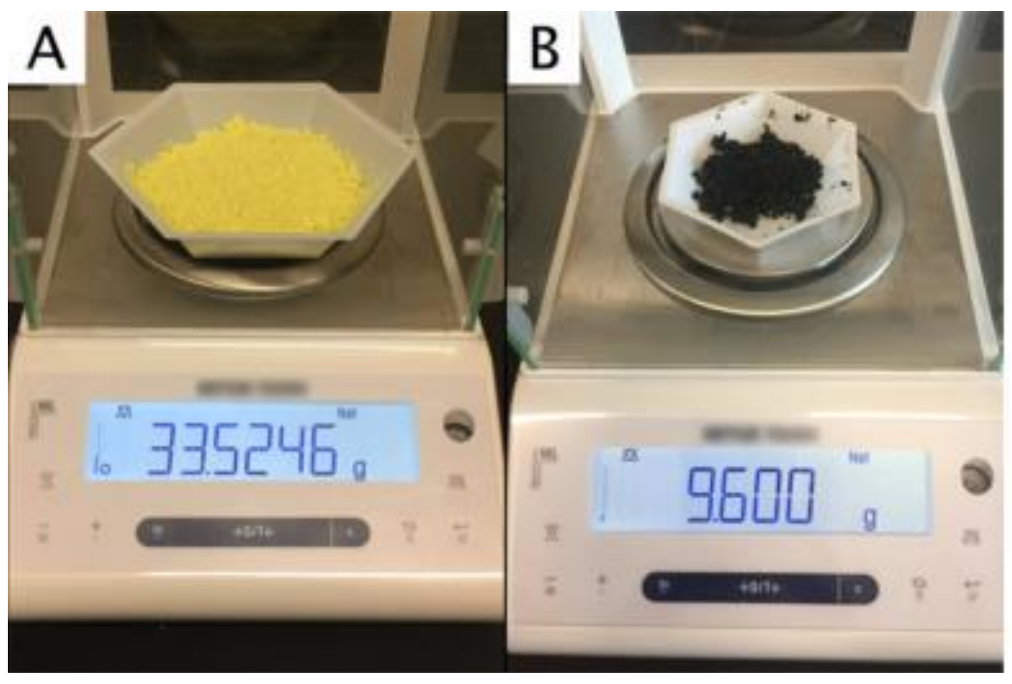

Figure 3: Products of large-scale synthesis and cation exchange. (A) CdS QDs. (B). Ag_2S QDs.

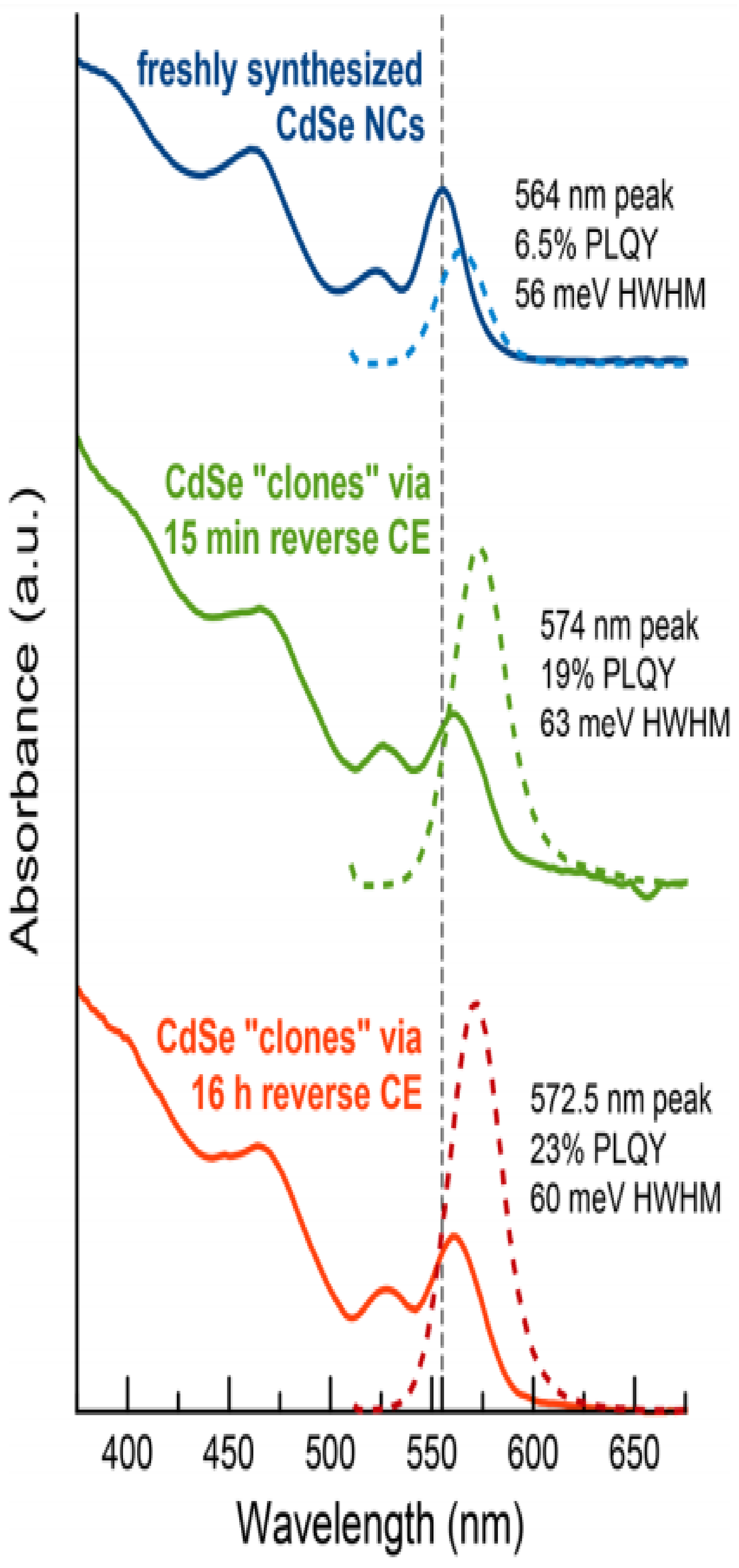

Figure 4: Absorption and Emission Spectra of forward and reverse CE reaction.

Future Works

Although significant progress has been made in terms of using CE as a route to device-quality nanomaterials, it is still difficult to dissolve a mobile cation in hydrophobic solvents. By tuning reactivity and solubility, the versatility and scalability of using CE can be improved.

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