Incorporation of Zinc in Pre-alloyed CuIn[Zn]S_2-ZnS Quantum Dots

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Background/Relevance

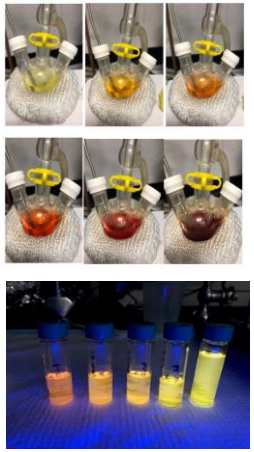
- Commercially available CdSe quantum dots, QDs, are not suitable for bioimaging applications due to their high toxicity.
- A solution to this issue is using $CuInS_2$ /ZnS QDs which do not contain heavy metals and have longer fluorescence lifetime but controlling the blinking of these particles remains an issue.

Innovation

- Incorporating zinc in pre-alloying steps to observe the behavior of the electronic and optical properties of $CuInS_2$ QDs.
- Establishing a direct correlation between the zinc composition of the QDs and blinking phenomena.

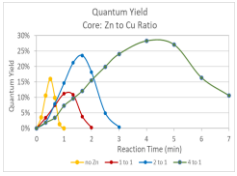
Approach

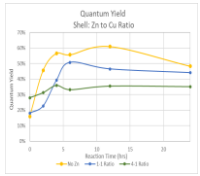
- Synthesis of the colloidal core QDs at 230°C using Cu^+, In^{3+}, Zn^{2+}, $and\ S^{2-}$ precursors, a high boiling point organic solvent and a ligand agent.
- Shelling process takes place at 230°C and lasts from six to twelve hours.
- Quantum yield is calculated from absorption and emission data.
- A fluorescence lifetime analysis is performed.
- Elemental analysis is done with ICP-MS.
- Characterization using a 100kV JEOL TEM

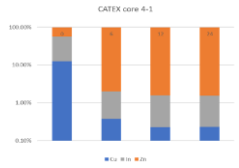


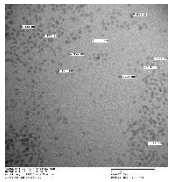
Key Results

- Increasing the amount of zinc while synthesizing the core increases the quantum yield, QY, from 15% to about 30%.
- Higher QY core QDs exhibited a smaller increase in QY upon shelling/cation exchange than those with no or little zinc.
- After 24 hr of cation exchange/shelling the QDs are composed of >98% ZnS.
- TEM size analysis shows heterogenous size distributions that increase as a function of shelling reaction time.









Conclusions

- Incorporating zinc in the core synthesis step influences the electronic and optical properties of both alloyed core and post cation exchange.
- The ratios of Cu and In change as the cation exchange reaction progresses.
- Cation exchange of the core QDs yields a heterogeneous size distributions.

Future Work

- Characterization of QDs using XRD and XPS
- Investigation of blinking properties
- Potential applications on time-gated imaging, FLIM, bio-tracking.