Enhancement of Photoluminescence of Aqueous ZnSe Quantum Dots by Addition of Ammonium Chloride

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Introduction

- Quantum dots are excellent tool for bioimaging for its photostability and photoluminescence properties.
- ZnSe is a potential quantum dot as Zn is nontoxic for human.
- Previously, Dr. Wei-Heng Shih’s lab has developed the synthesis of aqueous ZnSe quantum dots.

Results and Discussion

- pH effect on ZnSe QDs
  - Three different pH range (9-10, 10-11, 11-12) were chosen for ZnSe QDs synthesis.
  - Both the edge position in absorption and the emission peaks in photoluminescence have a red shift with increasing pH. At pH 11-12, an obvious edge state peak (~380 nm) appears.

- Ratio effect on ZnSe QDs
  - Three different MPA:Zn:Se ratio (8:3:1, 10:3:1, 12:3:1) were chosen for ZnSe QDs synthesis.
  - Both the edge position in absorption and the emission peaks in photoluminescence have a blue shift with increasing MPA ratio. At MPA:Zn:Se = 8:3:1, both edge and trap state peaks are exhibited.

- Ammonium Chloride effect on ZnSe QDs
  - ZnSe QDs with different ammonium chloride to selenium mass ratios (NH₄Cl:Se = 0:1, 10:1, 30:1, 40:1, 60:1, 70:1) were synthesized.
  - When the ammonium chloride to selenium ratio is less than 40:1, compared with previous ratios, the trap state emission reduces. However, the edge state emission keeps increasing to almost double the value with the ratio 40:1.
  - With large amount of ammonium chloride, the edge state emission can surpass the trap state emission.

Materials and Preparations

- Quantum Dots (QDs) Preparation
  - 3-mercaptopropionic acid (MPA)-capped zinc selenide (ZnSe) QDs with ammonium chloride for the molar ratio of MPA:Zn:Se = 8:3:1 were synthesized by aqueous method and exhibit photoluminescence (PL) edge state emission peak at ~ 360 nm and trap state emission peak at ~ 480 nm. (visible blue)[4]

- Elemental composition of ZnSe QDs was measured by Energy Dispersive Spectroscopy (EDS) characterization.
- After the addition of ammonium chloride, the S/Se ratio increased by ~400%
- Surface coating by ZnS
  - From literature review, most ZnSe QDs with edge state occurred by ZnS surface coating. The S comes from decomposition of 3-mercaptopropionic acid (MPA). There are many methods to decompose MPA capping molecule such as Ultra-violet light illumination or hydrothermal treatment.
  - Later our lab did the direct ZnS coating on ZnSe QDs, which also shows the increase of edge state peak in PL emission.
- However, we are still unknown about the mechanism of MPA decomposition by ammonium chloride.

Future Work

- Study the mechanism of how ammonium chloride works for enhancement of edge and trap state emission by FTIR characterization.

References

1. myssd.edu