05 ZnSe Quantum Dots as Trackable Gene Delivery Vehicles

Sophia Chen [a], Ruchi Kalola [a], Huy Pham [a], Xin Yang [a]
Advisors: Dr. Wan Y. Shih [a], Dr. Wei-Heng Shih [a], Dr. Ajay Kuriyan [b]

[a] School of Biomedical Engineering, Science and Health Systems, Drexel University, [b] Wills Eye Hospital

DREXEL UNIVERSITY School of Biomedical Engineering, Science and Health Systems

NEED

- Neurovascular age-related macular degeneration (wet AMD)
  → Leading cause of adult blindness
  → 196M patients globally [1]
- **Incomplete cure** → Gene therapy
  → **Viral vector limitations**
  - Trigger immune reaction, damage genes, $$$ production
- Researchers develop **non-viral gene delivery system**
  → **Location tracking** is **critical**
- **Quantum Dots** (QDs) fluoresce
  → **Trackable**
  → **Modifiable for gene delivery**

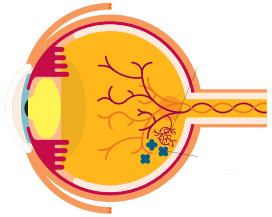


Figure 1. Wet AMD Eye: Excess VEGF causes abnormal blood vessel growth

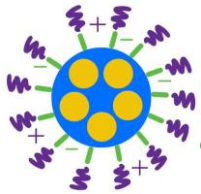


Figure 2. QD drawing: QD core (blue, yellow), capping molecule, gene carrier (polyethyleneimine/PEI)

OBJECTIVE

Formulate a **stable**, **non-cytotoxic**, and **trackable** QD for gene delivery applications.

KEY CONSTRAINTS

Cytotoxicity	QDs with heavy metals can be toxic
Complexable with gene carrier	QDs are complexed with PEI for gene delivery (tends to lower brightness)

KEY REQUIREMENTS

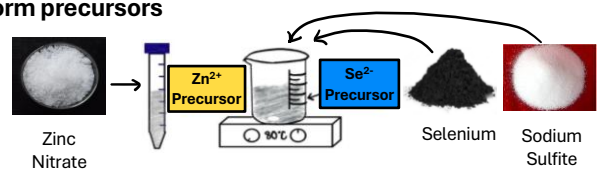
Maintains brightness after PEI complexing	> 200,000 a.u. Peak at 450-500 nm
Size after complexing	< 35 nm diameter
Charge after complexing	> 20 mV

REFERENCES

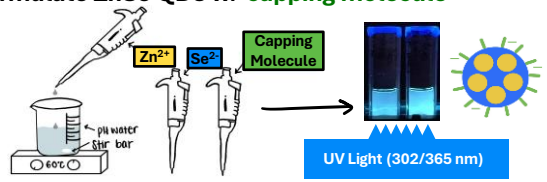
[1] W. L. Wong et al. The Lancet Global Health, 2014; 2(2): e106-e116

SOLUTION

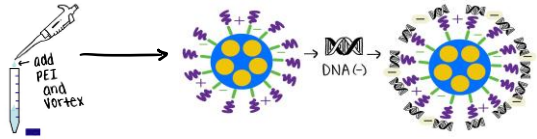
1) Form precursors



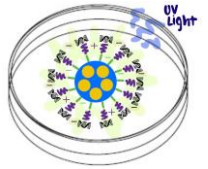
2) Formulate ZnSe QDs w/ capping molecule



3) Complex w/ gene carrier (PEI) and add DNA

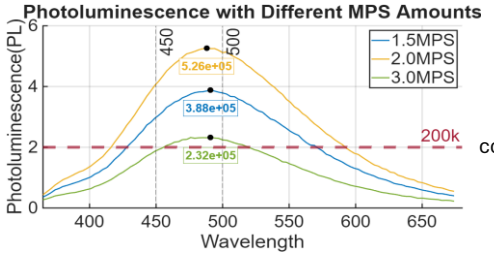


Final Result: Zinc Selenide QDs complexed w/ PEI and DNA, which glows when UV light is emitted



RESULTS

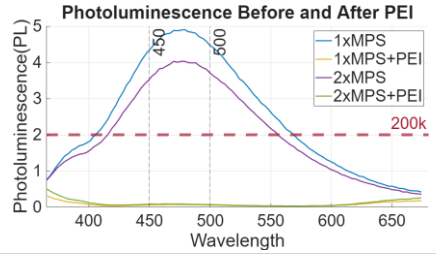
Capping Molecule Concentration Effect on *Brightness*



Spectrophotometer Results:

Brightest QD at 2x concentration capping molecule

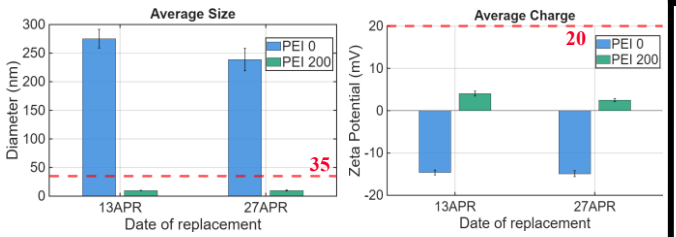
QD + PEI Complexing Effect on *Brightness*



Spectrophotometer Results:

PEI complexing → full loss of brightness

Size and Charge of QDs

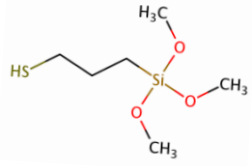


Zetasizer Results:

Partial success: < 35 nm & Positive Charge → Charge too weak; not positive enough
Further work required: PEI complexing / QD stability

CONCLUSION

- **Innovation: Non-cytotoxic, capped ZnSe QDs**
  → Safe, stable, trackable
  → No heavy metals
- **Successes**
  → Achieved peak brightness
  → Identified ideal capping molecule
- **Impact**
  → Provide foundational data for future studies
  → Alternative treatment research for 196M patients



MPS

ACKNOWLEDGEMENTS

Thank you to Dr. Wan Shih for her guidance and Drexel Biomed for their support.