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Shaping the Quantum Future with Core/Shell Quantum Dots

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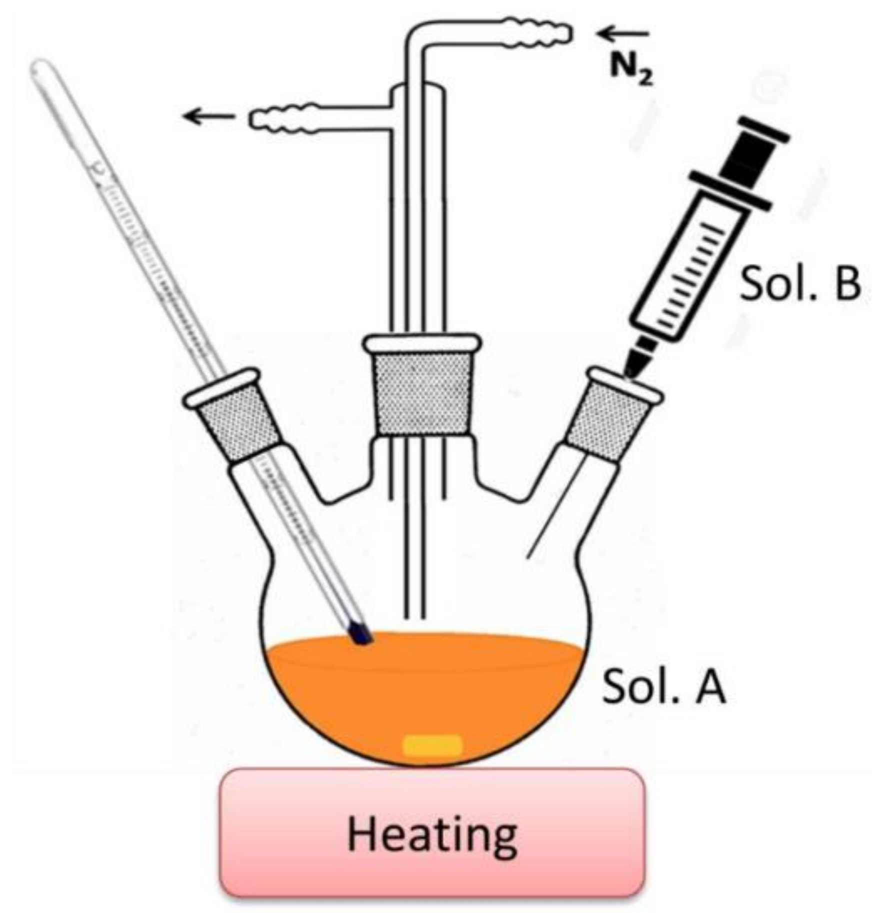
INTRODUCTION & AIM

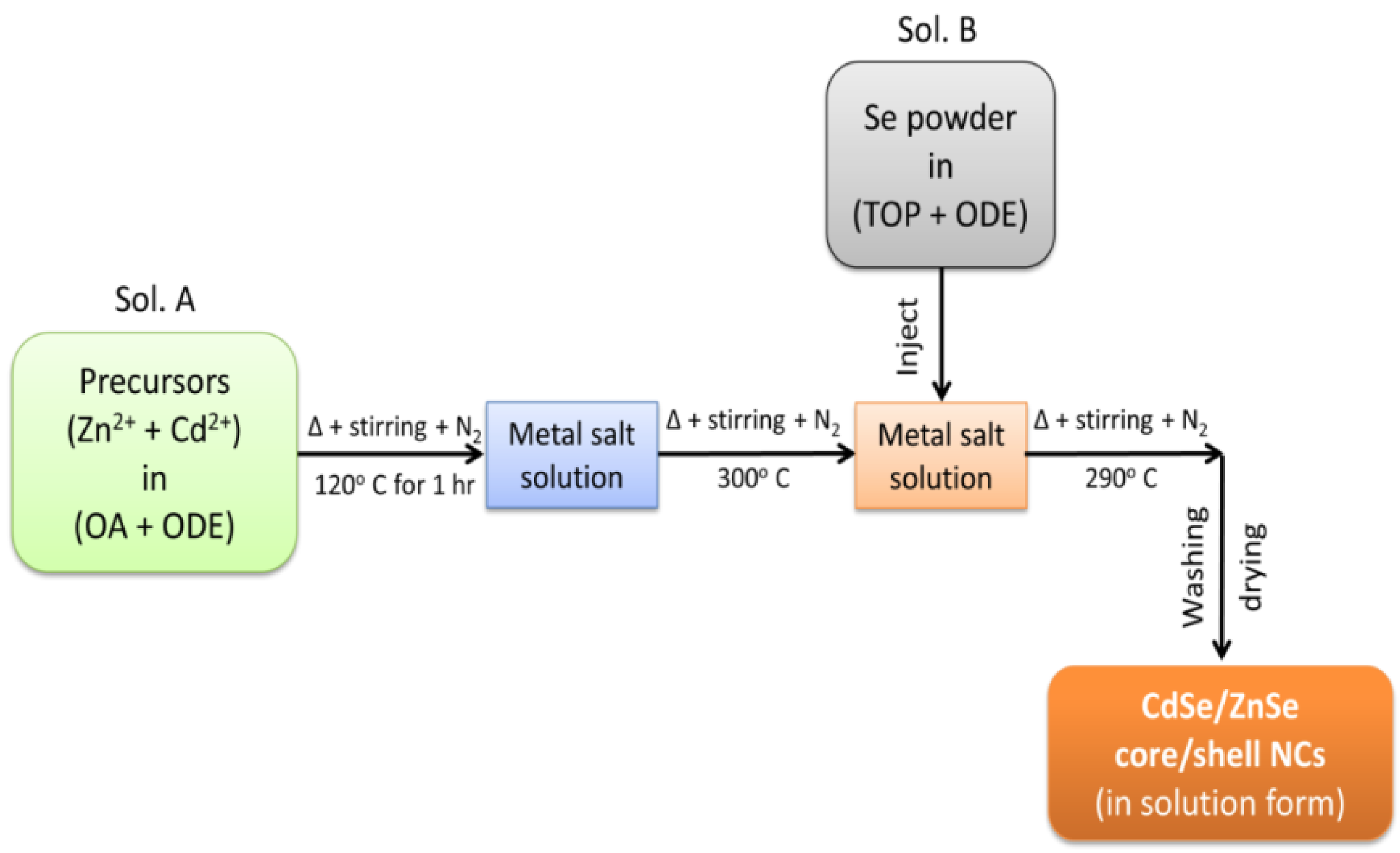
Quantum dots (QDs) are three-dimensionally confined semiconductor nanoparticles that have been extensively studied to meet the demands of modern applications. Among them, core/shell QDs have emerged as highly versatile nanostructures that integrate quantum confinement with engineered band alignment, offering superior optical stability, high quantum yield, and reduced non-radiative losses compared to bare QDs. Beyond chemical stability, the shape, size, and surface modifications of core/shell QDs critically influence their optical and electronic properties, thereby governing effective carrier confinement. By spatially separating the optically active core from a passivating or electronically engineered shell, core/shell architectures suppress surface trap–mediated non-radiative recombination and spectral diffusion, resulting in higher quantum yields, improved photo-stability, and tunable band alignments for charge and exciton confinement. These attributes position core/shell QDs as promising materials for next-generation technologies.

Colloidal core/shell QDs provide solution processability, high brightness, and tunable band structures that support on-chip integration and scalable quantum-emitter arrays, though challenges remain in minimizing charge leakage and noise as well as enhancing surface/ligand stability.

SYNTHESIS METHOD

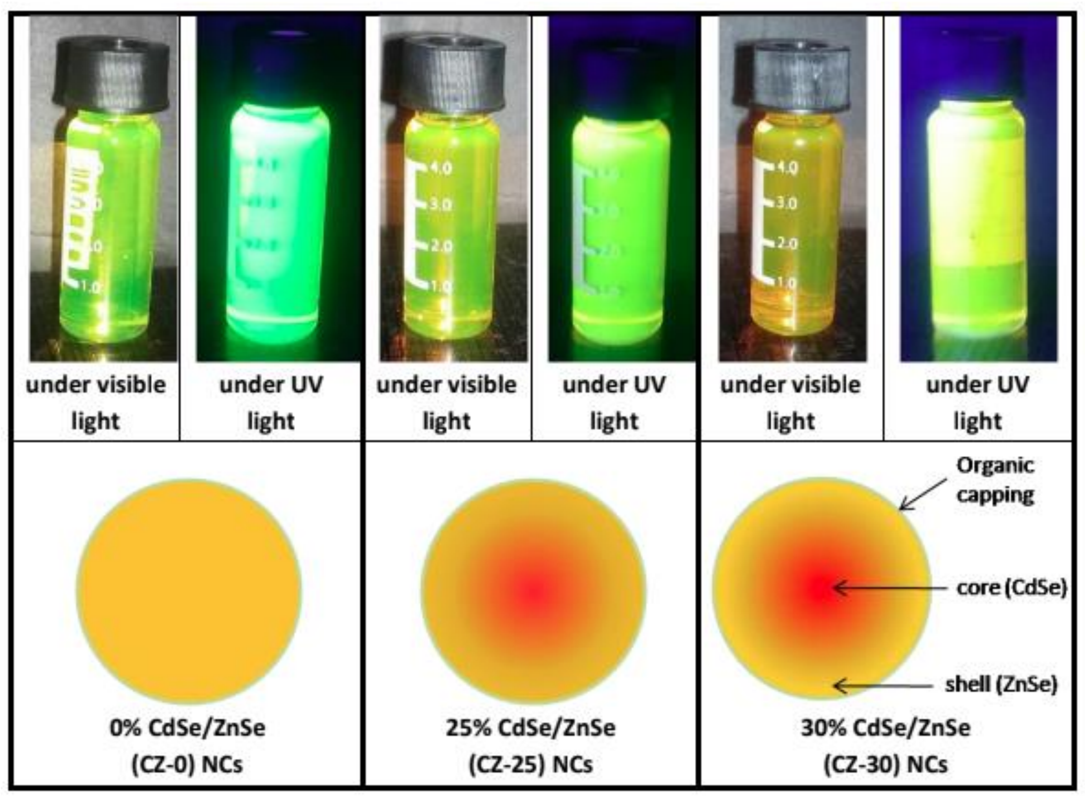


Set up for hot injection chemical method for synthesis of core/shell QDs,

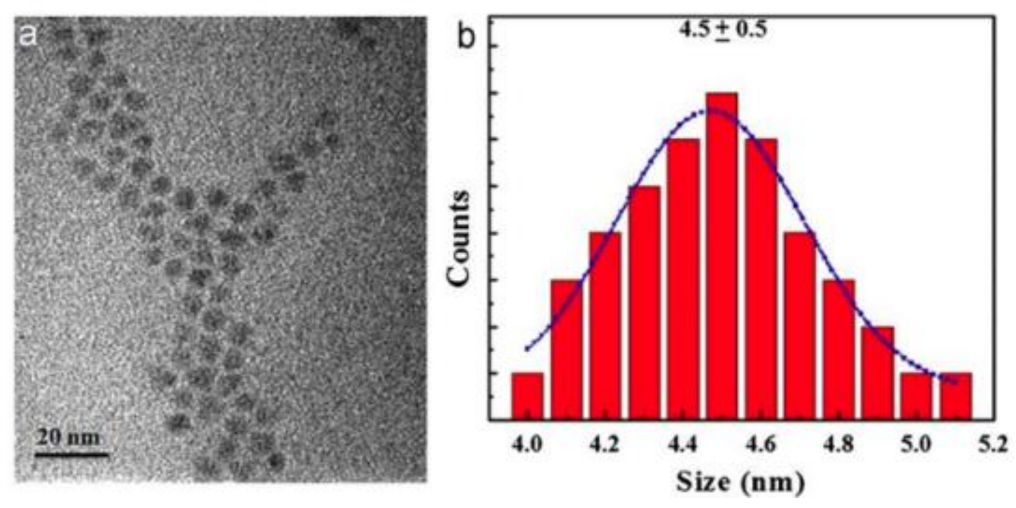


Flowchart depicting steps involving in synthesis of CdSe/ZnSe core/shell

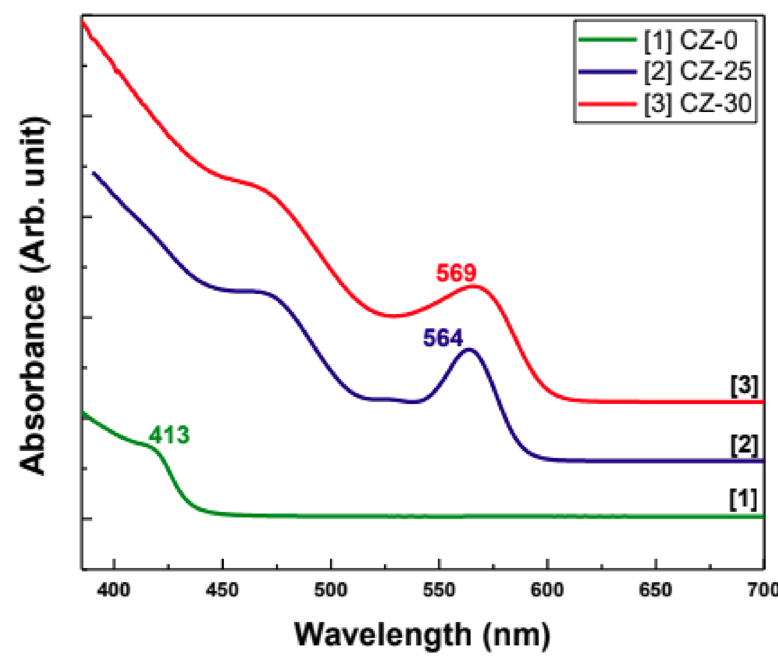
RESULTS & DISCUSSION



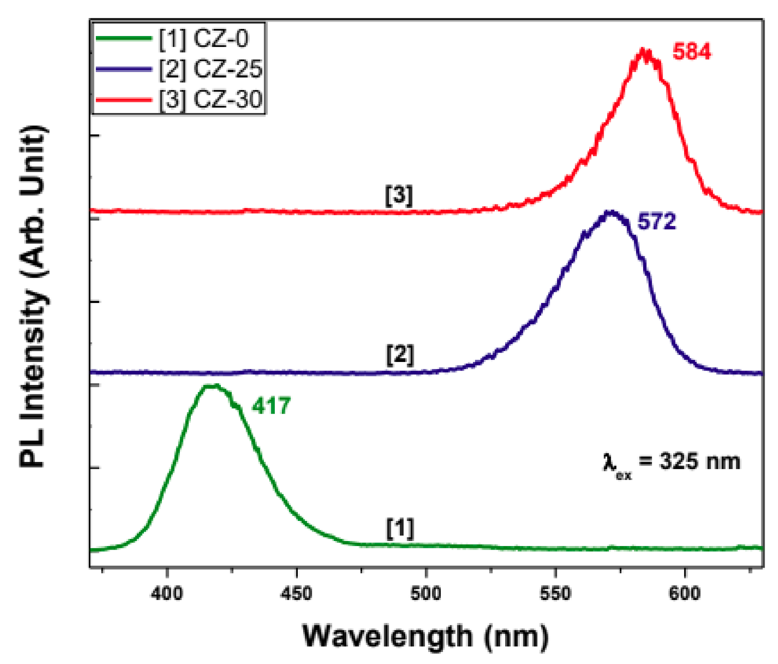
Picture of QDs suspension solution in visible and UV light, and pictorial representation of CdSe/ZnSe graded core/shell NCs.



(a) TEM image and (b) histogram showing size distribution of 25% CdSe/ZnSe core/shell (CZ-25) NCs at RT (adopted from ref. [4]).



Optical absorption spectra



PL spectra

CONCLUSION

Core/shell QDs combine material-level strategies (band engineering, shell passivation) with device-level integration (cavities, photonic circuits) to provide a practical pathway toward scalable quantum devices.

FUTURE WORK

- Advances in growth chemistry, decoherence suppression, and material integration are shaping next-generation quantum technologies.
- Research focuses on optimized core/shell architectures, scalable and eco-friendly synthesis, and AI-driven material design.
- Emphasis is placed on seamless integration into quantum computing, sensing, and communication devices.

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