Type-II Core-Shell Quantum Dots: Syntheses, Characterization and Photoinduced Charge Transfer Studies

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by

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Summary and Future Prospects

Abstract: *This chapter summarizes the outcome of the present work highlighting the conclusions. The future prospects of the work are also visualized.*

7.1 Summary of the work

The aim of our research work was the synthesis of novel type-II core-shell quantum dot systems, their charge transfer studies and also the fabrication of a quantum dot sensitized solar cell employing a type-II system. To meet the objectives, the following studies have been carried out:

i Synthesis and characterization of novel CdSe -Cu_2Se QDs.

ii Study of charge transfer between CdSe-Cu_2Se QDs and methyl viologen.

iii Synthesis and characterization of novel $CuInS_2$-In_2Se_3 QDs.

iv Synthesis and characterization of ZnTe-ZnSe QDs.

v Study of charge transfer between ZnTe-ZnSe QDs and methyl viologen.

vi Fabrication of QDSSCs based on CdSe-Cu_2Se QDs and characterization.

The studies are discussed in chapters 3 to 6. Chapter 3 focuses on a "green synthesis" and the photoinduced charge transfer studies of CdSe-Cu_2Se core-shell QDs. Highly crystalline and monodisperse type-II CdSe-Cu_2Se core-shell QDs were synthesized using organometallic hot injection method. The crystallinity and monodispersity of the nanostructures were confirmed from the HRTEM images. The core-shell structure was verified indirectly from absorption and emission spectra. EDS and XPS studies were done to identify the composition. XRD pattern suggested a hexagonal structure for the sample. The charge separation in the core-shell structure was proved by an electron transfer study. The efficacy in the charge separation in the novel CdSe-Cu_2Se system makes it a good choice for designing efficient light harvesting devices.

Chapter 4 discusses the synthesis and characterization of $CuInS_2$-In_2Se_3 core-shell QDs, another type-II system, using a two step method, employing "green" protocols. The nanostructures were spherical with well-defined lattice planes as evident from the HRTEM images. The chemical composition was analyzed using EDS, ICP-AES and XPS studies. A tetragonal chalcopyrite phase was identified in the system from the XRD analysis. The bandgap measurements were carried out using optical absorption and CV measurements. The absorption spectra, covering the entire visible region and extending to the NIR region, indicates that the system is capable for use in photovoltaic applications.

Photoinduced charge transfer studies of ZnTe-ZnSe type-II core-shell QDs is the theme of chapter 5. Oleic acid capped ZnTe-ZnSe type-II core-shell QDs were synthesized by a two pot colloidal organometallic synthesis method. The nanostructures were characterized using HRTEM, EDS, EDS, HRD, XPS and ICP-AES studies. The charge transfer capability of the core-shell structures with methyl viologen was verified using steady state and time-resolved photoluminescence studies, indicating a static charge transfer mechanism.

Chapter 6 discusses the fabrications of quantum dot sensitized solar cells using CdSe-Cu_2Se core-shell QDs. The cell structures were grown by assembling the QDs sensitized photoanode (FTO/TiO_2) and the Cu_2S brass counter electrode with a drop of polysulfide electrolyte between them. A ZnS passivation layer was also grown over the QDs layer for performance upgradation. By subjecting the QDs-sensitized photoanodes to a sintering process, we could fabricate solar cells of efficiency 4.83%.

7.2 Future Prospects

The future initiatives can be centred on:

i growth of more type-II core-shell QDs systems.

ii growth of type-II QDs systems of other geometries like dimers, multipods, dumbbells, etc.

iii detailed pump probe transient absorption studies of the above systems.

iv fabrication of QDSSCs based on the above systems.

v integration of intermediary layers in the cell structures.