Synthesis, Characterization and Assessment of Optical Properties of Different Water-Soluble Quantum Dots (QDs): Some Exploration of Their Potential Applications

Abstract and Keywords

Abstract: The focus of the thesis is to explore of optical properties of water-soluble different quantum dots (QDs) and carbon dots (C-dots) for their potential application as sensors (both chemo and bio-sensing). Nanomaterials are the leading edge of the rapidly developing nanotechnology. The ever increasing demands for biological and sensing applications of nanomaterials in aqueous media have drawn considerable attention toward the synthesis of water-soluble QDs. Hence the development of simple, facile, and low-cost routes for synthesis of water-soluble quantum dots (QDs) to effectively promote their applications in aqueous media can be of greater significance and naturally can draw more attention in recent times. Both hydrothermal and microwave-assisted methods can be used for direct aqueous synthesis of water-soluble different QDs. For practical applications of QDs as an efficient optical sensor, improvement of their optical properties (e.g. photoluminescence) is of prime importance. In that aspect, generation of highly photo-luminescent QDs or the development of efficient nano-sensor-based fluorescence assay for the detection of water soluble toxic ions or small biomolecules (or drugs) still remains very challenging for researchers. Water soluble CdS QDs were synthesized by hydrothermal method using mixed thiol capping agents (both MPA and TLA) which is further showcased that the selectivity as well as sensitivity of QDs toward two different metal ions (Ni2+ and Pb2+) *via* photoluminescence (PL) turn-off based strategy can be tuned as per linear combination principle (LCP), and that is found to hold good as a function of mole percentages of capping agents employed during synthesis. Herein, a ZnS QDs-based fluorescent chemo-sensor has been developed for super-selective detection of soluble ppb-level total arsenic [As(III) + As(V)] in aqueous system *via* aggregation enhanced emission (AEE) characteristic and also demonstrated potential application for the determination of total arsenic in real water samples. Furthermore, water-soluble N, P-doped carbon dot (C-dot) as efficient fluorescence resonance energy transfer (FRET)-active carbon nanomaterial with proflavine (PF) biomolecule has been studied and also assessed the FRET efficiency in different surfactant media and finally explored the possible application as a model drug delivery vehicle. We offered a never-before simplistic model to explain the possible origin of PL as well as excitation-dependent PL behavior (popularly known as, spectral migration) of C-dots which is an unique spectroscopic signature with the help of cocktail of fluorophores. So, in a nutshell, the general objectives of this entire thesis are to synthesize, characterize and analysis of optical properties of water-soluble different types of quantum dots (QDs) for their potential application as sensors (both chemo and bio-sensors) and model drug delivery vehicle (carrier) utilizing mainly photoluminescence (PL) method.

Keywords: Quantum dots (QDs), carbon dots (C-dots), photoluminescence (PL), water-soluble sensor, linear combination principle (LCP), cocktail of fluorophores, hydrothermal method, microwave-assisted method, excitation-dependent PL, spectral migration, fluorescence resonance energy transfer (FRET), capping agent, metal ions, sensing, aggregation enhanced emission (AEE), surfactant, PL quenching, drug delivery vehicle, and potential application.

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