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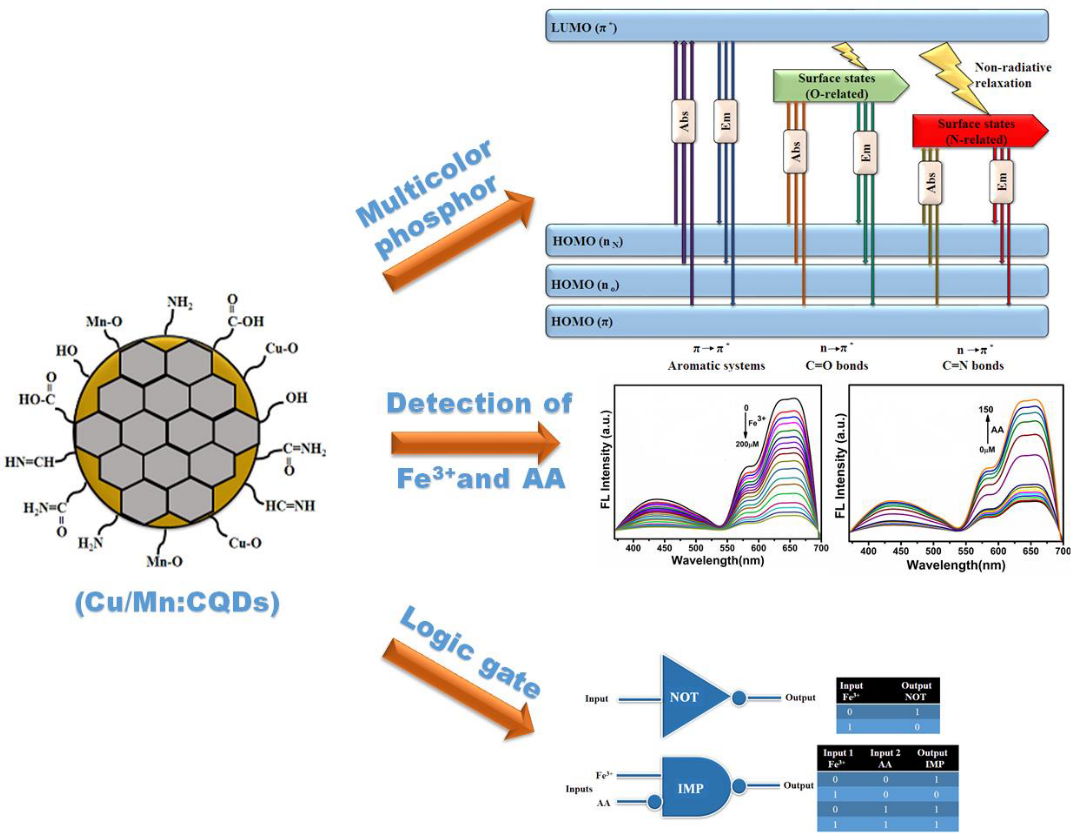
Title of the thesis: *Study of Luminescent and Functionalized Quantum Dots for Photonic Applications*

Abstract

The growing interest in QDs stems from their potential to revolutionize various fields of science, technology, and research. These include luminescent sensors, nano-scale display devices, quantum computing, lasers, white LEDs, solar cells, imaging of diseased cells, and detection of hazardous metal ions. Given the vast applications of QDs in current scenario, this thesis work involves (1) synthesizing and characterizing QDs for their potential use as optical sensors specifically fluorescent sensors and their utilization as phosphor in white LEDs, (2) testing the applicability of some QDs as highly effective/selective metal ion sensors, (3) creating a multicolor phosphor for white LED that is both economical, high-performing, and eco-friendly.



We have presented synthesis of water-soluble carbon quantum dots (CQDs) using gelatin as a precursor through hydrothermal treatment. Interestingly, the addition of Fe^{3+} ions to the CQDs solution resulted in fluorescence quenching, indicating a sensitive response of the CQDs towards Fe^{3+} ions. By evaluating the concentration range of 0-50 μM, the calculated limit of detection (LOD) for Fe^{3+} ions were determined to be 0.2 μM, with a high correlation coefficient (R^2) of 0.996. Additionally, when applied to monitor trace levels of Fe^{3+} ions in tap water, the CQDs exhibited acceptable recoveries ranging from 103-105%. The introduction of heteroatoms into carbon nanomaterials can cause both luminescent and structural changes, presenting an effective means of adjusting their structural and optical properties. We have successfully modified the luminescent properties through Cu and Mn doping, resulting in the creation of white fluorescent Cu and Mn-doped carbon quantum dots (Cu/Mn:CQDs) with an enhanced quantum yield of 28.35%. These Cu and Mn-doped quantum dots, were utilized as fluorescent sensors capable of highly sensitive detection of Fe^{3+} and ascorbic acid (AA) detection through "on-off-on" sequential mode. Impressive detection limits were achieved in nanomolar range and real sample analysis was also conducted. Therefore, the objective of developing a single phosphor as a white light emissive material has been effectively accomplished, resulting in an improved Color Rendering Index (CRI) value of 89. This breakthrough overcomes the significant limitation of expensive lanthanide-based phosphors.

Another aspect explored in the present study is the enhancement of the optical properties of ZnS QDs by incorporating dopants. The Mn^{2+}/Eu^{3+}@ZnS QDs were specifically designed as a sensitive fluorimetric chemosensor for detecting Cu^{2+} with the limit of detection (LOD) of 0.136 μM. The findings of this study indicate that the addition of Mn and Eu to ZnS quantum dots can significantly improve their photoluminescent colors. Also, the investigation into the simultaneous doping of Co^{2+} and Ag^{+} ions into ZnS quantum dots (QDs), resulting in QDs that exhibit exceptional capabilities for detecting Hg^{2+} ions with an excellent linear range of 0-50 μM, a correlation coefficient of 0.989, and a detection limit of 0.13 μM. The inclusion of dopants in the ZnS QDs led to an increase in solid-state fluorescence and a significantly higher quantum yield (27.6%). These phosphors possess impressive CIE chromaticity coordinates, favorable CCT values, and a high color purity of 91.1%, making them suitable for various applications in displays and demonstrating exceptional efficiency as red phosphors.

Keywords: *Carbon QDs, ZnS QDs, PL enhancement, phosphors, fluorometric sensors, white LEDs.*