Preface

Carbon nanomaterials have gradually garnered the scientific community's attention and have emerged as novel valuable materials. Carbon, one of the most plentiful substances on earth, and its allotropes such as fullerenes, carbon nanotubes, and graphene and carbon quantum dots have been proposed in the past two decades for energy generation, sensing, bio-imaging, and drug delivery due to their exceptional qualities and ease of production. Carbon quantum dots (CQDs) are recognized as zero-dimensional materials (diameters as small as 10 nm) with enhanced optical and electronic properties such as intense fluorescence, high electron mobility, bio-compatibility and high stability. Since their accidental discovery in 2004 during the purification of single-wall nanotubes, CQDs have been intensively explored and applied in numerous fields during the past two decades. Compared to semiconductor quantum dots, CQDs are predominantly composed of a carbonous core, making them biocompatible and non-toxic. They can be employed as biomarkers, metal sensors, optical sensors, light-harvesting material, fluorescent ink, anti-cancer agents, and possible drug delivery agents because of the inexpensive precursor material. Multiple studies have demonstrated that CQDs can be produced at high temperatures and pressure from various starting materials while retaining similar photo-physical properties. It would be advantageous to investigate further the optical and electronic properties of CQDs. Their sizes and shapes have been well examined regarding the morphology of CQDs. Although the study of nanostructured carbon materials has witnessed a rapid expansion and remains an active research topic, fundamental understandings of the growth mechanisms and essential elements responsible for synthesizing CQDs are still lacking. Carbon-based nanomaterials are currently regarded as a milestone in nanotechnology because they expedite scientific advancement and have numerous industrial uses. This thesis discusses various strategies for synthesizing and incorporating carbon nanomaterials into sensing, bio-imaging, and optoelectronic systems. The synthesis methods of carbon quantum dots have been examined in depth using various spectroscopic and microscopic techniques. CQDs have been synthesized utilizing different plant leaves as precursors and water and ethanol as solvents at varying temperatures, depending on the application.

This thesis also investigates the applications of CQDs in sensing and bio-imaging. We demonstrate that the optical and morphological properties of CQDs can be tuned by varying the hydrothermal synthesis temperature from 120°C to 230°C. We have functionalized CQDs with chlorophyll utilizing chlorophyll-rich banana leaves in ethanol as a carbon source because chlorophyll dissolves easily in ethanol which is less hazardous than other organic solvents. CQDs synthesized at 160°C can be used as a dual probe sensor for the selective detection of Hg^{+} ions and As^{3+} ions with lower detection limits. In another study, chlorophyll-rich CQDs were evaluated for their anti-cancer potential in cervical cell lines. We have also shown that CQDs can be used to detect ammonia gas and lead in drinking water. This thesis also discusses the application of carbon nanomaterials such as CQDs and carbon nanotubes to optoelectronic devices. We have exhibited CQDs as an electron transport layer in OLED for the first time. Due to its large specific surface area, high electron mobility, plentiful surface defects, and active sites, a thin film of CQDs has been produced by spin coating to form an electron transport layer in OLED. We have fabricated thin layers of carbon nanotube-doped green polymer as the emissive layer in OLED and OLET to improve these devices' performance. Doping SWNT increased luminosity and decreased threshold voltage. In addition, we have fabricated a VOLET by putting a capacitor on the top of an OLED. This extraordinary device has two functions: it generates light as an OLED and switches current as a transistor. Using the gate electrode, it is simple to adjust the current and luminosity of VOLET. This device will operate at low voltage due to its vertical integration, providing a solution for display applications. This work will provide crucial information regarding the characteristics of carbon nanostructures, enabling researchers to move forward and explore the untapped potential of CQDs, improve present research, and develop new applications for this unique class of nanomaterials.