Chapter 5: Conclusions and Future Work

The objective of this dissertation was to study the properties of different types of nanoparticle/polymer composites. The motivation for this choice of research area was based on the fact that for many applications nanoparticles often need to be dispersed in a polymer matrix. Different methods may be used to disperse them in a polymer, and different properties based on the initial properties of the nanoparticles may be obtained for the resulting composite.

In this study, two types of nanoparticles were used: Single-Walled Carbon Nanotubes and Quantum Dots (QDs). Chapter 1 comprised an extensive review of the literature focusing on Carbon Nanotubes. It presented the structural features and properties of Carbon Nanotubes, different means of purifying and solubilizing or dispersing them in an aqueous or organic solvent, as well as selected applications. Chapter 2 presented a comparison of the optical limiting properties of Single-Walled Carbon Nanotubes (SWNTs) dispersed in chloroform using three different conjugated polymers. Two rigid conjugated polymers, Poly(2,5-dioctylphenylene-1,4-ethynylene) (PPE), and Poly(9,9-dioctylfluorenyl-2,7-yleneethynylene) (PFE), and one flexible conjugated polymer, (Poly(9,9-di-n-hexylfluorenyl-2,7-diyl) (PFO) were utilized to dispersed the SWNTs. The results obtained showed that the optical limiting properties depended on the type of polymer used to disperse the SWNTs. PFE/SWNT dispersions gave slightly lower optical limiting performances when compared to PFO/SWNT and PPE/SWNT dispersions. The diameter of the bundles of SWNTs was evaluated by Atomic Force Microscopy (AFM) for each conjugated polymer/SWNT solution, and it was found that the PFE/SWNTs dispersion presented the smallest bundle diameters when compared to the PFO/SWNT and PPE/SWNT dispersions. Smaller diameters were responsible for the formation of smaller solvent or carbon vapor bubbles, which in turn induced lower diffraction of light and lower optical limiting performances. Future work for this project would involve the visualization of the interaction of the conjugated polymers with the SWNTs with Scanning Tunneling Microscopy, and further characterization with Raman spectroscopy.

Chapter 3 was focused on the spontaneous assembly of Polyamidoamine (PAMAM G4) dendrimer molecules induced by SWNTs. In this case, it was demonstrated that adding SWNTs to a solution of dendrimer molecules and subsequently drying the resulting dispersion produced straight and extended dendritic features. Future work for this project would involve the study of the electronic properties of the patterns, as well as the fabrication of patterns based on different sizes of dendrimer.

Finally, Chapter 4 presented a new fabrication method for dispersing Quantum Dots (QDs) in a polymer matrix. Three sizes of CdSe/ZnS QDs were used: 2.1, 2.6, and 4 nm. The initial CdSe/ZnS QDs dispersed in toluene were transferred into water by ligand exchange with 2-dimethylaminoethanethiol. The positively charged water-soluble QDs were further transferred into a hydrophobic ionic liquid by cation transfer. The resulting solution was used as a compatible medium for the polymerization and cross-linking of PMMA networks. Transparent and fluorescent composites were obtained. The quantum yields of the composites depended on the initial properties of the CdSe/ZnS QDs used, medium size QDs (2.6 nm) giving a better quantum yield than smaller (2.1 nm) or larger size QDs (4 nm). The dissimilarity observed was attributed to the different surface qualities of the QDs surface. Future work for this project would be the study of the degree of cross-linking of these composites, and the determination of their mechanical properties. Another area of interest would be the study of the nonlinear optical properties of thin films of QDs/polymer obtained by using our method of fabrication. A systematic study of the flexibility of the composites correlated with the amount of ionic liquid present in the composites would equally be of interest, as well as the development of higher surface area self-standing flexible films. These composites would also be interesting materials for the fabrication of Light-Emitting Devices (LED).