Abstract

Molecular self-assembly is a ubiquitous process in cell biology and materials science which associates small molecules rather than atomic units in a bottom-up approach to construct complex biological structures and nanobiomaterials with tailored properties and functions. The first part of the present thesis unravels the development of different self-assemblies of important biomolecules present in the cellular environments such as proteins, lipids, fatty acids forming vesicles and fibrils. Some reliable microscopic and spectroscopic techniques have been used to characterize these self-assembled systems. Besides, a wide range of dynamical processes occurring inside these self-assembled structures including water dynamics, rotational dynamics, conformational changes of the biomolecules and translational diffusion can be monitored using fluorescence spectroscopy (ensemble average and single molecule measurements). The second part of the thesis demonstrates the designing and the basic optical properties of different metal and carbon-based nanomaterials and their subsequent fluorescence based bioanalytical applications. For the further development of this field, we need to understand how the physicochemical properties of these newly engineered nanomaterials can be related to the biological behavior and how those properties influence their interactions with the biomolecules such as nucleic acids, proteins, peptides, cell membranes and organelles.

We have investigated how dimethyl sulfoxide (DMSO) modulates the structure and dynamics of the phospholipid and fatty acid bilayers. Fluorescence lifetime imaging microscopy (FLIM), solvation dynamics, rotational anisotropy, translational diffusion have been performed to probe the structural alteration of these systems. Several deadly neurogenerative disorders including Alzheimer's disease and and Parkinson's disease are caused by the self-aggregation of proteins. Using FLIM and fluorescence correlation spectroscopy (FCS), we have shown that surface active ionic liquids (SAILs) have the potential to inhibit the protein fibrillation. Recent research in the field of nanotechnology for multimodal applications of the novel nanomaterials motivates us to contribute in this developing field. We have designed fluorescent gold nanoclusters (Au NCs) having tunable emission using quite facile synthesis procedure. Their unique optical properties, high photostability and insignificant toxicity makes them more potent for bioimaging and sensing applications. The *in vitro* temperature sensing and amyloid sensing capabilities of the Au NCs have been demonstrated employing FLIM and FCS. Furthermore, we have studied the interaction mechanism of the duplex deoxyribonucleic acid (DNA) with graphene oxide (GO). Two different DNA binding probe molecules, 4'-6-diamidino-2-phenylindole (DAPI) and ethidium bromide (EB) have been used to monitor the nano-bio interaction by using different time resolved fluorescence spectroscopy.

Keywords: Self Assembly, Nanomaterials, Biocompatible, Nanothermometry, Time-resolved Fluorescence Spectroscopy, FLIM and FCS.