Abstract

In this thesis I have investigated ultrafast processes in confined media including micelles, micro-emulsion, vesicles and polymeric nanoparticles (NPs) mimicking well known biological assemblies. This is particularly significant given the difficulties and complexity in application of spectroscopic tools inside biological systems. The photophysics of drug molecules were investigated by monitoring excited state intramolecular proton transfer (ESIPT) process. Solvation dynamics studies are essential for understanding the distinctive structural features of water at the molecular level. Application of Förster resonance energy transfer (FRET) is useful to comprehend the structural heterogeneity of the biological systems. Fluorescence Correlation Spectroscopy (FCS) serves as an effective tool to measure dynamics and hydrodynamics of biomolecules.

At present, curcumin draws much attention due to its numerous pharmacological activities such as anti-inflammatory, antitumor, antioxidant, and other medicinal benefits. In spite of various advantages, the problem associated with curcumin is its low bioavailability and poor water solubility. To solve these issues we have monitored the photophysics of curcumin in aggregates like micelles and reverse micelles. However, as these systems are not suitable in drug delivery we have also studied the photophysics of curcumin in polymeric nanoparticles (NPs). Three different biocompatible random copolymers were synthesized that have been utilized to form polymeric nanoparticle (NP). It was observed that all the polymeric NPs were capable of incorporating curcumin as well as have the ability to modulate ESIPT process occurring in curcumin. The rate of curcumin degradation was drastically suppressed inside all the polymeric NPs.

Water molecules at the surface of biomolecules exhibit unique properties from those observed in the bulk, termed as biological water, a long standing interest to the scientific community. The characteristic features of water molecules near the interface where, the hydrogen bonding network gets locally perturbed, differ significantly from those in the bulk and thus, pose a set of interesting dynamical problems. We have measured the dynamics of water in biologically relevant self-assemblies, such as micelles and reverse micelle (micro-emulsion) as controllable model system. The decelerated relaxation dynamics of water was monitored with various coumarin dyes, due to immobilization of water molecules inside these assemblies.

Surface active ionic liquids (SAIL) are more biocompatible and environmental friendly compared to room temperature ionic liquids (RTIL) and have the capability to form organized assemblies. A unique class of SAILs was synthesized and applied to prepare IL-in-oil microemulsions as well as large unilamellar vesicles (LUVs). We have identified the different zones of IL-in-oil microemulsions applying FRET. FCS technique was also employed to study the interaction between BSA and these novel aggregates. The FCS results suggest that the diffusion time as well as size of the protein increases upon interacting with vesicles formed by the SAILs.

Keywords: Organized Assemblies, Microheterogeneous Systems, RTILs, SAILs, Fluorescence Technique