Abstract of the Thesis

This thesis deals with the study of the diffusion dynamics of small molecules using NMR spectroscopy and molecular dynamics simulations. The contents of the present thesis have been divided into six chapters whose brief account is sketched below:

Chapter 1

This chapter contains an introduction to the basics of NMR spectroscopy, molecular dynamics and molecular diffusion. The physical basis of the NMR signal, the FID and spin magnetization, T_1 and T_2 relaxation processes are discussed in the beginning. The pulsed fifield gradient NMR technique to measure translational self-diffusion coeffificients is described in detail. The basic flflowchart for a molecular dynamics simulation is explained and the force fifields and other constraints used in the GROMACS molecu lar dynamics software package is discussed. The fundamentals of molecular diffusion have been explained on the basis of Fick's laws of diffusion.

Chapter 2

The dynamics of drug molecules inside liposomal drug carriers is important from the point of view of understanding their biological interactions. Molecular dynamics sim ulations are extensively used to study the self-assembly of lipid bilayers and drug pen etration into these membrane mimetics. This chapter describes a study using molecular dynamics simulations on a flfluorinated drug diffusing inside a lipid bicelle (simulating a drug carrier environment). The conformational and transport properties of the drug inside a bicelle made from a mixture of DMPC/DHPC molecules are studied. The ef fect of temperature and bicellar phase on these structural and dynamic properties have been investigated. The computations show that the drug molecule is able to penetrate viiinto the lipid bilayer and drug molecule diffuses anomalously inside the bicelle.

Chapter 3

This chapter describes an NMR spectroscopic study of the temperature dependent dy namic behavior of $LiClO_4$ mixtures of various polyethylene glycols (PEG)-based poly mers in three different molecular solvents viz. water, dimethyl sulfoxide (DMSO), and acetonitrile (ACN). Temperature dependent NMR self-diffusion coeffificients, spin lattice (T_1), and spin-spin relaxation (T_2) studies has been performed in order to un derstand the dynamics of these mixtures. Protons from the ethylene oxide (EO) unit ($-OCH_2CH_2-$) of polymers have been probed through NMR spectroscopy for its study of chemical shift, diffusion and relaxation studies. It has been observed that the in creased temperature of the medium shows a deshielded chemical environment for the protons of EO unit in its D_2O and DMSO mixtures, however a shielded chemical en vironment has been observed in its ACN mixtures. On the other hand, the hydroxyl proton shows opposite behavior in its mixtures with ACN and DMSO, which is ex plained on the basis of the H-bonding phenomenon. Increasing temperature of the medium decreases the hydrodynamic radius of polymers and has been explained on the basis of solvation/desolvation phenomenon. A substantial interaction between the lithium cation with the EO unit of the polymer has been observed as probed through ^{1}H-^{7}Li 2D HOESY spectroscopy. The Li-H distance has been calculated by applying the isolated spin pair approximation and the shortest Li-H distance has been observed in its DMSO mixtures as compared to its ACN mixtures suggesting a stronger interac tion between the Li+ cation with the polymer cage in its DMSO mixtures.

Chapter 4

Studies of the dynamics and conformation of polymer chains in ionic liquids are of great interest as they have wide-ranging applications in fuel cells, batteries and gas sep aration. Different binary mixtures of polymers and ionic liquids could exhibit dramatic variations in their properties such as solubility. Since it is diffificult to perform exper iments on dilute polymer/ionic liquid mixtures, theoretical investigations are quickly gaining ground in this novel area. In this chapter, the conformational properties of poly(ethylene glycol) (PEG) in a prototypical ionic liquid 1-methylimidazolium chlo viiiride ([MIM][Cl]), are studied using molecular dynamics simulations. The effect of temperature and of chain length on these conformational properties are investigated. The dihedral angle distribution has also been computed which suggests that at lower temperatures the polymer chain has a fifinite probability of adopting a helical conforma tion in the ionic liquid.

Chapter 5

Curcumin is a hydrophobic polyphenolic compound derived from the roots of the herb *Curcumalonga* and exists in both keto and enol forms. Curcumin is an interesting compound due to its pharmacological effects including anti-inflflammatory, antioxidant, antiproliferative and anticancer properties. This chapter describes a molecular dynam ics study of the conformational flflexibility and dynamics of curcumin inside a lipid bilayer. The lipid bilayer is constructed from dipalmitoylphosphatidylcholine (DPPC) molecules which have a hydrophobic tail and a hydrophilic head. To analyze the dif fusion of curcumin in the lipid bilayer, the mean square displacement is studied with time. To investigate the conformational flflexibility of curcumin, the radius of gyration and the distance between the oxygen atoms of the hydroxyl group are computed. The free energy of the solvation of curcumin inside the DPPC bilayer is also calculated.

Chapter 6

This chapter contains a brief summary of the main results of the present thesis, their applications, as well as their possible future extensions.