Recent advances in the design and fabrication of novel microfluidic platforms have made a paradigm shift in micro and nano scale flow; control, monitoring and analysis in a number of applications especially in biomedical applications. Based on the configurations and techniques of fluid handling and manipulation, microfluidics platform can be divided into two distinct sections, namely, closed and open microfluidics with their specific uses and advantages. The work presented in this thesis addresses scientific issues involved in novel applications of both open and closed microfluidics. In the closed microfluidics platform (Part A), the capillary force driven flow of water in a polydimethylsiloxane (PDMS) microchannel is investigated. The flow is achieved by enhancing the hydrophilicity of a inherently hydrophobic PDMS surface by oxygen plasma treatment. The effect of plasma treatment on the surface properties (roughness and hardness) and the concomitant changes in the flow velocity are also examined in detail along with a theoretical model correlating the various effects. In the second part of the thesis (PART B) evaporation induced self assembly of proteins, namely Aβ(25-35) peptide, human serum albumin (HSA) and lysozyme, in open microfluidic configurations are studied. These proteins are relevant in protein fibrillation studies that provide platforms for understanding neurodegenerative diseases. Influence of fluorescence micro and nanoparticles on the dried pattern of HSA and lysozyme have been studied and distinctive features are extracted by image analysis. This methodology is further extended to develop a quick quantification method for HSA fibrils and compared with the conventional method (far-UV circular dichroism). Additionally, the effect of physical parameters (e.g., surface wettability, rate of evaporation) on the drying pattern of Aβ(25-35) are evaluated in presence of Thioflavin T, a fibril binding dye. The relevant physics at the contact line region of a droplet in terms of the relevant forces and their effect on the evaporation process are probed. The formation of the 'coffee rings' and specific patterns during the drying of a sessile colloidal (containing proteins) droplet are investigated (both qualitatively and quantitatively) to examine the interesting phenomena with significant applicative potential in greater details.

Keywords:

Microchannel, Capillary flow, Plasma treatment, Human serum albumin, Lysozyme, Aβ(25-35), Coffee ring effect, Evaporation, Microparticle, Nanoparticle, Protein fibrils, Fluorescence microscopy, Surface wettability, DLVO forces, Capillary force, Clustering