Topic: Rheology and dynamics of sheared, dense colloidal suspensions

Various industrial and consumer products come in the form of dense suspensions. While the mechanics of dilute/semi-dilute suspensions are well understood, our knowledge of dense suspensions (volume fractions > 0.5) is still incomplete despite a lot of work. The macroscopic properties of a suspension are determined by the spatial organization of particles which is known as the microstructure. When subjected to flow, the suspension microstructure can reorganize into anisotropic structures which would affect the rheological properties thereby possibly altering the flow profile itself. We plan to study the physics of such systems using a model colloidal suspension (e.g. few hundred nanometer sized monodisperse PMMA/PS/Silica micro-particles immersed in a density and refractive index matched Newtonian liquid).

The micro-rheology i.e. the local dynamics, and the structure of suspension will be probed using laser induced fluorescence imaging. The proposed experiments are focused on visualizing the flow behaviour of a dense colloidal suspension (hard and soft) which is subjected to an oscillatory shear on a stress/strain controlled rheometer using a parallel plate shearing assembly. Two different set-ups have been fabricated for this work. One using a laser sheet to fluoresce a vertical plane between the parallel plates at one particular radius. The other one uses an incandescent lamp to visualize the flow across the entire radial plane at one particular height. In both cases the tracers will be identified and tracked while they are moving under the influence of shear. From these we will get the velocity profiles in the system in the radial as well as the vertical direction, thus giving an idea about the 3-D behaviour. These 3-D velocity profiles will give us an indication of the possible slip, shear banding taking place in the rheometer. The global flow behaviour will be probed using various linear and non-linear rheology probes.

The data will be analyzed to eventually link up the micro-level (particle level: flow profiles, structure etc.) behavior with the global rheology. In the long term, we plan to visualize the particle motion in a shearing assembly under a fast laser scanning confocal microscope. This would help us in observing the changing microstructure of the suspension under the influence of shear in addition to the flow profiles. Correlations between these two studies will help understand the intimate coupling between flow and microstructure. Research in this area is expected to elucidate the role of microstructure in determining the performance of suspensions as well as in controlling the manufacturing of suspensions.