

The physics of microgels and other soft colloids

Supervisors: Dr. J. Mattsson (physics), Dr. Olivier Cayre (Engineering) and Prof. B. Murray (Food Science)

Summary: *The behaviour of crowded systems of soft colloidal particles is not well understood and this project aims at addressing key open questions*

Description: Transitions where a material goes from a fluid state to an arrested but still disordered state arise in a diverse range of systems (colloidal dispersions, molecular or polymeric fluids, granular systems, emulsions, foams, pastes, and biological cells). Colloidal dispersions made from 'soft' elastic microgels provide an excellent model system for such behaviour and are also industrially highly important. Microgels are used in applications including biosensing and medical diagnostics, in pharmaceutical delivery systems and switchable materials and are regularly used to control the rheological properties of industrial products such as paints, motor oils, foods, cosmetics and inks. Many applications of microgels are based on highly crowded states, but we presently have little understanding of the rich and fascinating behaviour that takes place in the packing of such soft colloids. This project is aimed at directly addressing key fundamental aspects of the physics of microgel dispersions where important open questions include how the motions of the microgel particles are correlated in time and space, how the motions, arrangements and rheology are affected by the individual microgel particle shape, elasticity (heterogeneity) and by the inter-particle interactions. An important component of the project is the use of the 3D-photon correlation light scattering set-up in Leeds, which will be combined with other light scattering techniques, microscopy and rheology as well as colloidal synthesis techniques to provide a full characterisation and control of these experimental systems.

Vitrimers – developing and characterizing a new class of supramolecular materials

Supervisor: Dr. J. Mattsson and Prof. Cliff Jones (physics) and Prof. A. Wilson (chemistry)

Summary: *To design and characterise so called vitrimers, a new type of supramolecular material, for the use in novel applications*

Description: Supramolecular materials are based on fundamental molecular units that link to form larger entities, such as clusters or networks. Both the fundamental units and their interactions can be designed to impart physical macroscopic properties including viscosity, mechanical rigidity or specific adhesion or transport characteristics. Advanced materials with highly tuneable and switchable properties can be produced that use triggers such as temperature, pH, pressure, optics or an applied electric or magnetic field. This project is aimed at the design and physical characterisation of a new type of supramolecular materials, so called vitrimers. These are made from small molecule or polymeric units which link to form an interconnected network. Remarkably, for vitrimers the network strength given by the number of network nodes stays fixed even though external triggers can drive the rate at which local topological network rearrangements take place. The latter allow

macroscopic shape changes (malleability) and controlled transport properties even though the network strength stays fixed. Advanced materials with highly tuneable and switchable properties can be produced that use triggers such as temperature, pH, pressure, optics or an applied electric or magnetic field.

Tuning selective gas transport in polymer films by manipulation of molecular orientation at different length scales

Supervisors: Dr Peter Hine and Dr Johan Mattsson

Summary: *To achieve selective gas transport properties in polymers by the detailed control of molecular orientations at different length scales*

Description: Polymer films are used extensively for packaging due to their processability, lightweight and transparency. The barrier properties of such films is, as would be expected, also a crucial property, particularly when used for food packaging. In some cases it is crucial to keep gases within the barrier, in other instances keeping gases from penetrating to the contents within. Occasionally it is also advantageous to have a specially designed barrier, which would allow selective transport of particular gases in either direction. One key aspect of the polymer film that can potentially be modified during melt processing, or a subsequent solid state processing stage, is the level of preferred molecular orientation within the film. If the rate of deformation used to manufacture the film is faster than the relaxation time of the polymer chain (often controlled by the entanglement time τ_e), then the polymer chains can be trapped in a preferred orientation. These effects might be used to custom design polymer films for important physical properties such as preferential gas transfer. The aim of this project is to assess whether preferred molecular orientation can be used to affect gas transport, and for what particular single gas (oxygen, nitrogen, water vapour etc) or gas mixtures. Careful annealing of oriented films can produce different levels of molecular orientation at different length scales, and the interest is to see if this can be used to tailor gas transport.

The project will use small scale, but relevant, processing facilities at Leeds to manufacture films with controlled levels of orientation. The trapped orientation, and its dynamics, will be assessed by a range of experimental techniques all available at Leeds including dielectric spectroscopy, birefringence, differential scanning calorimetry and rheology, as well as the important underpinning gas diffusion measurements,