Ionic liquids (ILs) are molten salts with melting temperatures \(<100\,^\circ\text{C}\). They have received much attention over the last ten years or so because of their interesting, and sometimes unique, combination of physical properties and because of their wide range of potential applications: \(\text{e.g.}\) from potentially green solvent systems to electrolytes in batteries and solar cells, and in biomass processing. An intriguing aspect of ILs is the fact that many display nano-scale ordering, driven by the phase separation of polar (ionic) and non-polar (aliphatic) parts of the constituent ions. Careful design of the constituent IL ions can then lead to materials displaying liquid-crystalline mesophases and there is scope for the formation of other self-organised structures (\(\text{e.g.}\) micelles). The ability to control self-organisation in ILs offers huge potential to tune their properties and may allow ILs to be used as liquid nano-reactors, as 1D- or 2D-conducting electrolytes or in gas storage/separation.

We have found recently that binary mixtures of ILs containing short- and long-chain cations (figure 1) in different proportions display bulk and surface structures that are dependent on composition (from isolated aggregates of the long-chained cation to a bicontinuous network of polar and non-polar domains). Crucially, the work showed that many physical properties (\(\text{e.g.}\) surface composition, conductivity) are a non-linear function of composition, which poses interesting questions concerning the co-solution behaviour. This project will extend these studies to ILs containing polar (ionic), aliphatic and fluorous domains where it is expected that competition between the demixing of fluorous and aliphatic chains, in addition to segregation of the polar and non-polar parts of the ions, will drive self-organisation.

During the project we will synthesise novel ILs containing both fluorous and aliphatic chains and create mixtures thereof, investigating their physical properties, structure and potentially their dynamics using techniques such as small-angle X-ray and neutron scattering (SAXS and SANS) at national facilities (ISIS & Diamond), polarised optical microscopy (POM), DSC and other general physical techniques including conductivity and viscosity, along with surface tension measurements will also be used. Once products have been synthesised and their structural properties studied the project will seek to develop the applications of these novel materials, for example as reaction media, electrolytes and/or in gas storage/separation.

A student working on this project will gain an extremely broad range of training from synthesis, through to materials characterisation and the use of large national facilities such as synchrotron X-ray sources and neutron beam lines. Through interactions with collaborators in Lisbon and at York a student on this project will also gain an understanding of the way that computer simulations can be applied to these systems to give valuable insight that is complementary to experimental studies. A student on this project will attend national and international conferences in relevant areas and have the opportunity to complement in-house training with national training courses (\(\text{e.g.}\) in neutron techniques).