Investigating the potential of ionic liquids to the self assembly of drug-polymer composites for drug delivery applications.

Supervisors: Dr Charlie Laughton[1], Dr Anna Croft[2], and Dr Ricky Wildman[2,3]

1. *Division of Medicinal Chemistry and Structural Biology, School of Pharmacy and Centre for Biomolecular Sciences.*
2. *Division of Manufacturing and Process Technologies, Faculty of Engineering*
3. *EPSRC Centre for Innovative Manufacturing in Additive Manufacturing*

Polymer-drug composites, such as nanoparticles and printed solid dispersions, are under active development as new materials that can solve long-standing problems in the delivery of “difficult” drugs, such as poor solubility and untargeted distribution. A common approach to the production of such materials is nanoprecipitation, in which, for example, a solution of the polymer in a water miscible organic solvent is mixed with an aqueous solution of the drug. This mixing may be done through a microfluidic device. The scientific principles behind the mixing and precipitation processes are currently poorly understood, such that it is very difficult to reliably design these materials. Recently we have shown that computational simulations, of a type more commonly used in structure-based drug design, can also be applied to these drug formulation problems, giving insights at the atomic scale into what drives recognition and assembly.

The aim of this project is, through a combination of both theoretical modelling and experimental work, to extend these studies from simple organic solvents to water-miscible ionic liquids. Ionic liquids are solvents that are composed entirely of ions, with their properties strongly driven by electrostatic forces and their properties being very different from molecular solvents. Moreover, there are a large number of combinations of different ions, leading to more than a million known ionic liquids, and many more binary and ternary combinations. Thus the understanding of specific interactions of ionic liquid components with the polymer, drug and water components are crucial to subsequent selection of an appropriate ionic liquids for an effective process. This project will therefore inform, at the microscopic level, what are the key drivers in the nanoprecipitation process (and how these differ from related processes with molecular solvents) through application of the above simulation techniques.

An understanding of how to scale the properties of these materials from the micro to macro scale will give us the ability to control size & morphology of these particles, as well as being able to control the composition. This will open up the possibility of being able to manufacture not only the particles themselves, but to be able to 3D print composites of well determined and behaved distributions of particle in matrix and in the future. Knowing the constitutive relationships underpinning the particle production and behaviour will eventually lead to us being able to “dial up” the material as required for individual, bespoke applications.

This interdisciplinary project would suit a graduate with a first degree related to chemistry, physics, pharmaceutical sciences or chemical engineering. It will provide training in state-of-the-art computational and experimental techniques applied to one of the most exciting new areas in drug formulation science and technology.