**Block copolymers to promote a bicontinuous morphology in epoxy/ionic liquid formulations during reaction-induced phase separation**

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Structural electrolytes which can perform two functions simultaneously, can be combined with carbon fibre electrodes and a separator in structural/multifunctional energy storage devices, such as supercapacitors. However, ionic conductivity and mechanical properties are inversely correlated. The most promising approach to overcome this correlation, is to create bi-continuous morphologies where one phase is responsible for ion conduction and the other mechanical strength. Epoxy-based formulations are one of the most studied systems for structural electrolytes, in which an epoxy resin (providing mechanical integrity) is cured in the presence of a combination of additives including ionic liquids, lithium salts, nanoparticles and organic solvent to introduce ionic conductivity.

The use of block copolymers to control blend morphologies is well-known. Epoxy resin blends undergo reaction-induced phase separation and the impact of block copolymers on morphology formation in epoxy/block-copolymer systems is understood. Recently Shirshova showed (paper in preparation) that it is also possible to use a block-copolymer to influence the morphology of an epoxy/ionic liquid blend, resulting in a reduction in domain sizes of bicontinuous phases and a promising combination of ionic conductivity and mechanical performance. However, a significant disadvantages of the use of these block-copolymers is that their synthesis required a time-consuming, multi-step RAFT polymerization, followed by multi-step purification of the resulting block-copolymers.

This project will focus on a systematic investigation into the impact of a variety of block-copolymers, both commercially available and designed and synthesised in-house. The latter will contain an epoxy-functionalized block, possibly based on recent work by Hutchings, and a second block of either PEO or bearing anions matching the ionic liquid. We will adopt a structure-property correlation approach to explore the impact of the chemical nature, molar mass, composition and architecture of the block-copolymers on the cured blend morphology, with a view to optimize ionic conductivity and mechanical properties. The rate of curing will also undoubtedly influence morphology and curing kinetics will be studied using DSC, rheology and FTIR. To establish the mechanism of the morphology formation during the reaction-induced phase separation in the epoxy/ionic liquid formulations, in the presence of block-copolymers, SAXS and/or SANS experiments will be carried out. The microstructures of the resulting polymers will be characterized using SEM, TEM and the most promising formulations would be tested to establish their ionic conductivity and mechanical performance.