Project title: Ternary Polymer Blends Involving Self-Reinforcing Liquid Crystalline Polymer Fibrils Containing Carbon Nanotube Reinforcement

Project number: IMURA0065

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Research Academy theme/s

Nanotechnology

The research problem

Liquid crystalline polymers (LCPs) are rigid chain materials with low melt viscosity, that are able to reduce the viscosity of polymers with which they are blended, whilst at the same time reinforcing them due to the high modulus of LCPs. Because of their ability to produce an elongated, fibrillar phase in blends with other engineering thermoplastics, these mixtures have been called “self reinforcing polymer blends”, with the internal liquid crystalline fibrils being of micron dimension. However, it has often been desired that the reinforcing phase could be much greater than the few GPa of LCP fibrils. It would be desirable to reinforce the LCP phase with nanoparticles. Ideal for this task would be the use of carbon nanotubes, these nanoparticles being both elongated and conductive and only modest amounts of work have been undertaken in incorporating them into liquid crystal polymers. The inclusion of anisotropic particles in LCPs is intrinsically interesting because it has been shown elsewhere that the alignment of the LCP chains could potentially enhance the alignment of incorporated additives, such as CNTs.

This project thus seeks to produce ternary blends (thermoplastic polymer + liquid crystal polymer + carbon nanotube) in which the internal LCP phase has much higher modulus due to inclusion of CNTs than in previous work, which then transmits this increased modulus to the blend as a whole, without increasing viscosity (indeed, the overall viscosity and thus processability) may actually be reduced compared to the matrix polymer alone. It is important to understand will be the role of CNT filler with the LCP fibrils, the effect on LCP viscosity and how this influences the morphology of the blend. In addition, the carbon nanotubes may reside in part at the interface of the LCP and matrix, and thus influence both the rheology, shape and interfacial adhesion of the two materials. The degree of orientation of the CNT within the fibrils is important to understand and to manipulate, and thus work on the ternary systems would be preceded by binary blend work involving CNT and LCPs. Another parameter available for manipulation is the nature of the nanotube surface, which can be modified in a range of ways. The fact that the nanotubes are conductive (as well as having a high modulus) provides additional interest and advantage to the blends.

Project aims

This project aims to develop new blends of self-reinforcing ternary polymer blends involving an engineering plastic matrix, liquid crystalline polymer fibrils which are reinforced by conductive, rigid carbon nanotube nanoparticles. These materials will potentially have improved rigidity and interfacial adhesion, without any sacrifice in processability of the materials.

Expected outcomes

- New ternary blends with tailored properties of high modulus and strength, with little change to viscosity
- An understanding of the effect of including carbon nanotubes and other nanoparticles in the low viscosity, fibrillar liquid cyrstalline phase, on the rheological properties, morphology and mechanical properties of the final blend

Which of the above Theme does this project address?

This work sits squarely in the area of nanomaterials, and thus nanotechnology, taking advantage of the small size and high surface area of the conductive carbon nanotubes

How will the project address the Goals of the above Themes?

Nanocomposites represent one of the most commercialised forms of nanotechnology, given the scale of the plastics industry. Often very useful results can be achieved by the addition of only very small amounts of materials and thus the project will have both fundamental and applied interest.