DEVELOPMENT AND STUDY OF SELF-REINFORCED BLENDS OF THERMOTROPIC LIQUID CRYSTALLINE POLYMERS WITH THERMOPLASTICS FOR ENGINEERING APPLICATIONS

By

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CERTIFICATE

This is to certify that the thesis entitled 'DEVELOPMENT AND STUDY OF SELF-REINFORCED BLENDS OF THERMOTROPIC LIQUID CRYSTALLINE POLYMERS WITH THERMOPLASTICS FOR ENGINEERING APPLICATIONS' being submitted by Ms. Geetanjali Sawhney to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by her. Ms. Geetanjali Sawhney has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to our knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted in part or in full to any other University or Institute for the award of degree or diploma.

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ABSTRACT

Liquid crystalline polymers (LCPs) are a relatively new class of materials which show anisotropy in the melt state or in solutions. However, their commercial and industrial applicability has been deterred by their relatively high cost. Melt blending thermotropic LCPs, as the minor component, with conventional thermoplastics gives rise to enhancement of the mechanical properties of the matrix polymer making the use of LCPs economically viable. The blends of LCPs with conventional thermoplastics are often referred as self-reinforced blends or 'in-situ' composites since the LCP forms fibrils "in-situ" in the presence of an elongational flow during processing. These LCP fibrils in turn provide a reinforcement effect, akin to short fibre reinforced composites. It has also been reported that the LCP acts as a processing aid because it reduces the viscosity of the matrix polymer.

The primary objective of this study is to develop and analyse blends of a thermotropic liquid crystalline copolyester with two engineering thermoplastics namely Triax 1180 (an alloy of polyamide -6 and ABS) and polybutylene terephthalate (PBT) with the LCP content varying from 5 to 20 wt %. In both blend systems, injection moulded test specimens showed that LCP enhanced the tensile and flexural properties of the matrix polymers with increasing LCP content.

Morphological studies revealed that LCP formed fibrillar structure in moulded samples with a skin-core effect. Highly oriented LCP fibrils constituted the skin layer while less oriented fibrils or ellipsoidal globules constituted the core region. The

development of fibrillar morphology and its effect on properties is strongly dependent on injection moulding parameters. Hence, a detailed study of the effect of processing conditions on the structure and properties was carried out for the Triax based blends. It was found that a lower barrel temperature, higher mould temperature, greater injection pressure, lower injection speed and greater residence time in the heated mould were more conducive to produce a better developed fibrillar morphology and in turn superior tensile and flexural properties. The samples with higher strength and modulus values correlated with the formation of a greater amount of oriented fibrils of high aspect ratio. However, the two parameters which showed the most significant effect were barrel temperature and mould temperature while the others had a relatively lesser effect. This study leads to optimisation of processing conditions.

Based on the studies on Triax/Vectra blends, for PBT /LCP blends only barrel temperature and mould temperature were varied. Here again it was found that a lower barrel temperature and a higher mould temperature caused greater enhancement of the mechanical properties of the blends. As was seen in the previous system higher strength and modulus values were accompanied by a greater amount of fibrils of higher aspect ratios.

Both the blends systems were analysed using standard composite theories for unidirectional fibre composites forming the upper limit and particulate filled composites forming the lower limit. The results for the two systems fell between the two limits showing a good agreement with the composite analogy.

It has been demonstrated that self reinforcing composites can be made by blending LCPs with engineering thermoplastics and that the processing conditions play a vital role in determining the mechanical properties and morphology of injection moulded blends. Such blends/composites can be used for a large number of commercial applications and form an important class of materials for the future since they would be easily processable as well as recyclable. Commercial exploitation of self reinforced composites would find a very important use of thermotropic liquid crystalline polymers.

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