8 Blends containing liquid crystal polymers

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8.1 Introduction

Liquid crystal polymers (LCPs) are used in many different commercial applications ranging from high modulus fibres (Kevlar) to microwave cookware (Xydar). Much of the driving force behind the development of LCPs had been the increasing desire to replace metal components with engineering polymers, for example in automotive and aerospace sectors. LCPs were proclaimed as a new class of engineering polymers, which would take a large share of this market. In the event they have achieved limited market penetration as engineering materials in their own right. Key properties turned out to be low thermal expansion coefficients leading to high quality mouldings, rather than exceptional modulus or strength. Suppliers have been withdrawing production from the area (e.g. ICI, Eastman Kodak). Over the same period commercial interest has grown in polymer blend technology. Thus it is not surprising that the focus of interest in LCPs has switched from their use as stand alone materials to their use in blends.

This chapter focuses on recent developments in the area of blends containing LCPs. A brief introduction to liquid crystals and LCPs is provided before the potential applications of LCP blends are discussed.

8.1.1 The nature of liquid crystals

A liquid crystal is quite simply a state of matter between the liquid and the crystal state. A liquid crystal is an ordered fluid. The possibility of order existing, at equilibrium, in a fluid arises when the molecules within the liquid are anisotropic. These anisotropic molecules must also resist entropic forces which would otherwise tend to turn a rod into a random coil. Rigid rods readily form liquid crystal phases. Rigidity is, however, not as strong a requirement as originally perceived. Several so-called ‘rigid rod’ molecules have in fact been shown to be close to random coils in solution [1]. Other factors, such as the preferred conformation of the chain, can prevent an anisotropic molecule collapsing into a random coil [2].

Almost any form of anisotropy can give rise to a liquid crystal phase (see Figure 8.1). Rods, discs, planks and helices are all well documented examples [3].
Many natural materials can exist in the liquid crystal state. Examples of common materials include DNA, cholesterol and tobacco mosaic virus. Probably the best known synthetic liquid crystals are those used in liquid crystal displays. Gray et al. [4] pioneered the breakthrough in this field with the development of cyano-biphenyls. Other common structural units include; para-linked benzene rings, cyclohexane, bi-cyclo [2, 2, 2] octane, stilbene, azo-links, etc. A comprehensive reference to liquid crystals is Kelker [5] which lists many of the chemical classes of material that exhibit liquid crystallinity.

There are many different types of liquid crystals but there are three main classifications as recognised by Friedel [6]: nematic, smectic and cholesteric (see Figure 8.2). The nematic state is ordered in one dimension only and is the least ordered liquid crystal phase. The smectic phase contains some form of two-dimensional order, such as layers, hence the term ‘smectic’. Cholesteric liquid crystals are twisted structures usually due to an optically active molecule. Cholesterol itself was the first example of these twisted structures, hence the name (see Marchessault et al. [7]).