

CHAPTER II

LITERATURE REVIEW

Blends of liquid crystalline polymers and thermoplastics have been studied by many researchers. The main aim in blending thermotropic LCPs is to achieve a composite structure and a mechanical reinforcement of the matrix polymers. Almost reviews were concerned with the liquid crystalline polymers. Few researches were reviewed with the blend of polymer and low molar mass liquid crystals. The literatures in this field are rarely found.

Buckley, A., Conciatori, A. B. and Calundann, G. W. [1984] used low molecular weight liquid crystalline compound to plasticize polyolefin and polyester. The melt viscosities of blends were reduced by as much as 25 to 30 percent compared to the melt viscosities of the pure polyolefin and polyester.

Siegmann, A., Dagan, A. and Kenig, S. [1985] prepared the polyblends of a liquid crystalline aromatic copolyester (based on 6-hydroxy-2-naphthoic acid (HNA) and p-hydroxybenzoic acid) and an amorphous polyamide (PA) by melt blending. The blends rheological behaviours were found to be very different from that of the individual components and very significant viscosity reductions were observed for the blends consisting of only 5%LCP. The blends viscosities were always much lower than that of the parent polymers (a factor of 20-25). The tensile mechanical behavior of

LCP/PA blends is very similar to that of polymeric composites. The blends two phase morphologies were found to be affected by their compositions

Kyu, T. and Ping Zhuang [1987] studied the blend of thermotropic liquid crystalline copolyesters and polycarbonates. The blend were found to form a miscible blend upon solvent casting from a mixed solvent of 60/40 phenol/ tetrachloroethane. The PC/PHB-PET blend undergoes phase separation during heat treatment exhibiting a miscibility window of a lower critical solution temperature.

Blizard, K. G. and Baird, D. G. [1987] characterized the morphologies of blends of polycarbonate and nylon 6,6 with a copolyester of 60 mole percent p-hydroxybenzoic acid / 40 mole percent poly(ethylene terephthalate). They found that some extensional flow are required for the coalescence and extension of the particulate LCP phase. Only a small (10 or 30 percent) weight fraction of LCP was required to reduce the viscosity of the thermoplastics to that of the polymeric liquid crystal.

Kyu, T. and Zhuang, P. [1988] investigated the system of thermotropic liquid crystalline copolyester (60% PHB-PET) and polycarbonates. They observed that PC and PHB-PET form a miscible blend under appropriate solvent casting conditions. Phase separation seems to occur via spinodal decomposition. Anisotropic liquid crystalline structure was presented within the phase-separated PHB-PET rich domains.

Malix, T. M., Carreau, P. J. and Chapleau, N. [1988] investigated the mechanical and rheological properties of blends of a thermotropic liquid crystalline polyester with a polycarbonate. The LCP that they selected was VECTRA based on p-hydroxybenzoic acid and 2,6-hydroxynaphthoic acid. They found that the melt viscosity of the blends was similar to that of the unblended polycarbonate, but more shear thinning and less viscous. The increasing of Young modulus by 100% are observed for blends containing only 10 percent of liquid crystalline polymer.

Nobile, M. R., Amendola, E. and Nicolais, L. [1989] prepared blends of polycarbonate (PC) and poly(ethylene terephthalate-co-p-oxybenzoate) (PET/PHB60) by melt blending. Concerning the rheological behavior of the PC/LCP blends, when low percentages of LCP (5 and 10%) were added, the flow curves of the blends resembled the rheological characteristics of the unfilled PC. The flow curve of the 50% LCP blend was highly shear thinning, showing that the LCP phase dominates the rheology of this blend. At the extrusion temperature of 240 and 260 °C, at high shear rates, a drop in the viscosity of the PC of about 30% and 50% was observed for the PC/5%LCP and PC/10%LCP blends, respectively. At lower shear rates the flow curves of the blends and of the PC overlapped.

Lenz, R. W., et al. [1989] studied phase behavior of blends of a liquid crystalline polymer with a non-LC polymer. The blends exhibited phase separation over the whole range of compositions studied as observed by DSC and dynamic mechanical analysis. The thermotropic LC polymer was found to be immiscible with a non-LC polymer of similar structure in the solid as well as in the melt state for blends over a wide range of compositions.

La Mantia, F. P., Valenza, A., Paci, M. and Magagnini, P. L. [1990] investigated the blends of nylon6 and a liquid-crystalline copolyesteramide (LCP). Blends of nylon 6 and a wholly aromatic LCP have been extruded at two different temperatures. The influence of the LCP content on the viscosity of the blends is better seen in Figure 2-1 and 2-2 where viscosity is reported as a function of the composition at fixed shear rate. A deep minimum is shown at both temperatures at a concentration range of the liquid crystalline component of 10-20% at 260 °C and 5-20% at 290 °C. The reduced viscosity have been interpreted in terms of formation of fibrils and of immiscibility between two phases.

Zaldua, A., Munoz, E., Pena, J. J. and Santamaria, A. [1991] studied the blend of P(HBA-ETP) copolyester with PBT. The viscosity of the blend is not decreased by the addition of a small quantity of LCP. But the viscosity decreases only for the blends of >40%.

Kulichikhin, V. G., et al. [1991] studied LC copolyester (PES) "Ultrax-4002" and polysulfone in terms of the morphology and physical-mechanical characteristics of the extrudates. The reinforcement of an isotropic matrix by LC polymers leads to a specific change in the strength properties of compositions. A maximum increase in the strength and initial modulus was observed for blends containing not more than 10% LC polymer.

Heino, M. T. and Seppala, J. V. [1992] investigated blends of a polyester type thermotropic liquid crystalline polymer (LCP) (Vectra A950) with polyethylene terephthalate (PET), polypropylene (PP), and polyphenylene sulfide (PPS). They concluded that LCP was found to act as

a significant reinforcement for all matrix studied. Tensile strength and elastic modulus of the blends increased with increasing LCP content and draw ratio, while strain at break decreased. The improvement in strength and stiffness was most significant at higher LCP contents (20-30 wt%). Also at these compositions, the effect of draw ratio was greater. Moreover, they found that the mechanical properties of their blends were closely related to the blend morphology. The melt viscosities of LCP and the pure matrices were quite similar in the shear rate range used in processing. However, at some shear rates PP was slightly less viscous than LCP.

Beery, D., König, S. and Siegmund, A. [1992] studied the shear and elongational viscosities of a thermotropic liquid crystalline polymer (LCP), polycarbonate (PC), and their 20%LCP / 80%PC blend by using a capillary rheometer. The LCP used was a wholly aromatic copolyester, composed of hydroxybenzoic acid (HBA) and hydroxynaphthoic acid (HNA) with 73/27 molar ratio. Experimental results have shown that shear viscosities and entrance pressures are practically independent of the entrance angles. The entrance pressure drop was small in the case of PC and reached 50% of the total pressure drop for LCP. The 20%LCP blend exhibits intermediate viscosity values. The elongational viscosities of the three materials studied are a function of elongation rate, and can be described by power law equations.

Lin, Y. G., Lee, H. W. and Winter, H. H. [1993] studied the miscibility and viscoelastic properties of blends of a segmented block copolyester (LCP) and poly(ethylene terephthalate). They found that addition of a small quantity of LCP has a dramatic effect on rheology. For example,

addition of 2 wt% LCP reduces the viscosity by about 60%. This effect is most pronounced for PET of higher molar masses. The melt viscosity decreases exponentially with the LCP content in the range of composition where the blends are miscible. But there was no significant further reduction of viscosity when the LCP content exceeds 50 wt%. Addition of LCP also changes the distribution of the relaxation times of PET and broadens the zero-shear viscosity regime.

Li, W., et al. [1994] studied the phase morphology and miscibility of binary blends of polyarylethersulfone (PES) and liquid crystalline polymer (LCP) of p-oxybenzoate and ethylene terephthalate units. They observed the phase inversion in blend, when the blends contained 50 wt% or more the LCP.

Lee, S., Mather, P. T. and Peason, D. S. [1996] investigated the phase behavior and rheology of binary blends of polycarbonate (PC) and a liquid crystalline polymer (LCP). Results of DSC and optical microscopy have indicated that the LCP is solubilized in the mixture for weight fractions of LCP less than about 0.05 and shows partial miscibility with PC over the rest of the composition range. Moreover, they suggested that there is some interaction between the separate isotropic and anisotropic phases, with complex viscosities of the blends being intermediate between pure components.

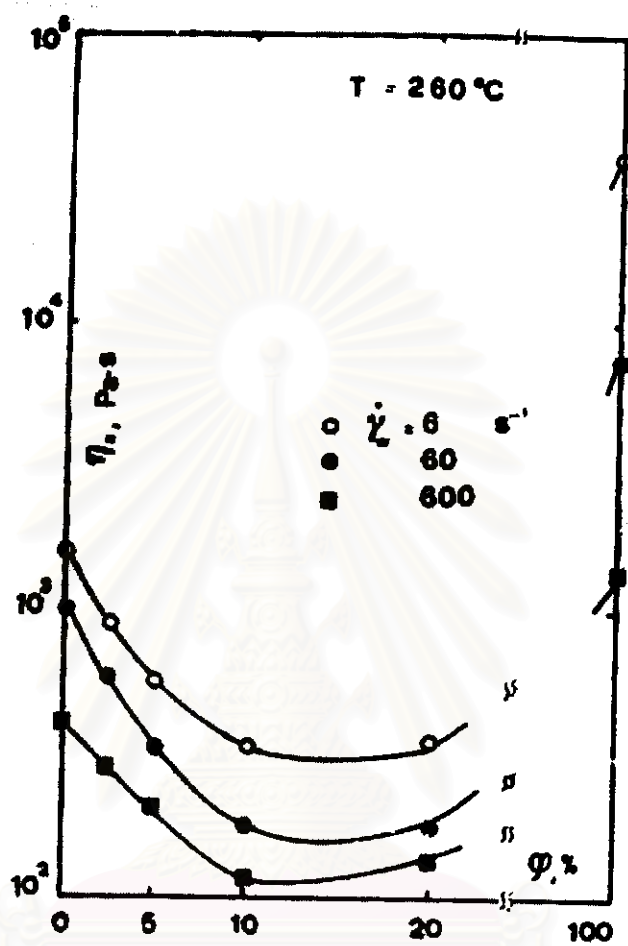


Figure 2-1 Viscosity vs LCP content at fixed shear rates. $T = 260^{\circ}\text{C}$.

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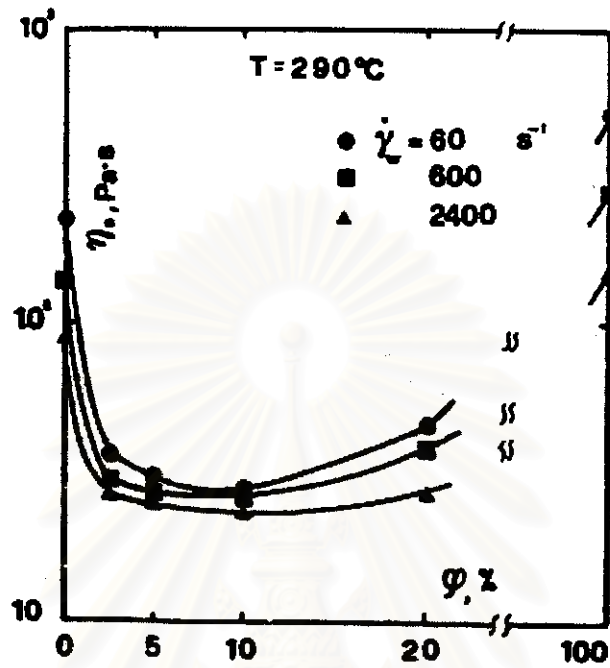


Figure 2-2 Viscosity vs LCP content at fixed shear rates. $T = 290^{\circ}\text{C}$.

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