



CHAPTER I INTRODUCTION

It is widely accepted that the mechanical strength and stiffness of polymers are considerably enhanced by introducing short glass fibers as reinforcing agents. However, conventional polymer composites reinforced with higher load of glass fiber are usually difficult to process owing to their high melt viscosity. Other difficulties encountered include wear of processing facility resulting from the abrasion of reinforcement and fiber breakage. To overcome these problems, blending of a thermoplastic with a highly rigid, non-abrasive component that does not impede the polymer flow would be fascinating. The potential replacement of glass fibers that meet such requisites is the thermotropic liquid crystalline polymer (LCP). Blending of an LCP with a thermoplastic (TP) also considered economically-effective as an LCP alone is too expensive to be used in domestic and some engineering applications.

Under optimized flow conditions, the LCP can align themselves and elongate to the direction of flow, resulting in a reduction in melt viscosity and superior mechanical properties. Thus the LCP/TP blends are usually termed 'in-situ composites'. The processing temperature could be manipulated to provide sufficient viscous force able to elongate the LCP domains. Recently, effects of temperature on the viscosity ratio and the resulting tensile properties on a system with a small viscosity ratio (the ratio of the viscosity of TP to that of LCP) were done but further study under higher viscosity ratio conditions was not yet performed.

Another factor that influences the physical properties is the extent of crystallization occurring during processing. The crystallization extent of the semi-crystalline polymer matrix can be affected greatly in the presence of an LCP. These crystallites are well-known to improve the polymer properties by acting as a physical cross-links tying segments of many polymer chains together and their high modulus compared to the amorphous part increases the overall modulus of the polymer. This change in the modulus is more pronounced at the temperature above the glass transition temperature. The alteration of the polymer mechanical performance by the presence of crystallites indicates the necessity for further investigation on the crystallization kinetics of polymer blends.

Although attempts have been made to gain LCP-reinforced thermoplastic with excellent mechanical properties, it seems that the outcome was not yet satisfactory. One of the main reasons is the limited mechanical improvements by the use of an LCP alone. This has led to a new approach so-called as in-situ hybrid composites. Such system consists of three components in principle: a minor LCP phase, a thermoplastic matrix, and an inorganic filler. The use of some inorganic fillers such as nanoclay and carbon nanotubes have been reported to improve the compatibility of the blends. The microscopic fillers like glass beads and glass fibers could manipulate the flow field and thus affect the LCP fibrillation. The difference in nature of these inorganic fillers are to be carefully selected to play a certain role in in-situ hybrid composites. It was demonstrated by some of the researchers that transesterification reactions can occur between two polyesters with no exception for an LCP copolyester, and the reactions can have serious effects on the polymer properties. This work selected zinc oxide (ZnO) as an inorganic filler to modify the mechanical performance of the composites with a further expectation to investigate its influence of the transesterification between poly(ethylene terephthalate) (PET) and Vectra A950 (a liquid crystalline copolyester), the system where the criterion for the occurrence of the transesterification can be met. Literature showed the possibility of ZnO to promote transesterification between dibutyl maleate functionalized poly(ethylene) (POF) and PET.

The other filler that has recently drawn increasing interest in both academia and industry is the multi-walled carbon nanotubes (CNTs). Thanks to its exceptionally high tensile strength, modulus, and electrical conductivity that make CNTs a promising candidate as a filler in a polymer composite where both mechanical and electrical properties are of great importance. These properties originate from the CNT structure; CNTs consists of cylinders of graphite sheets with a very high aspect ratio. Since CNTs are costly, there have been attempts to utilize the concept called "double percolation" to reduce the amount of this conductive filler while retaining the desired properties. This concept can be realized by confining CNTs in a continuous phase which can be one of the polymer components or at the polymer interface of the immiscible blend. We hypothesized that if the CNTs could be confined in a long, continuous LCP fibrils dispersed in a thermoplastic matrix, the

amount of CNT required to achieve a certain electrical conductivity would be reduced and the mechanical performance could be improved simultaneously. This work selected polycarbonate as a thermoplastic matrix and two grades of LCP used were Vectra A950 ($T_g = 100^\circ\text{C}$, $T_m = 280^\circ\text{C}$) and Vectra V400P ($T_g = 110^\circ\text{C}$, $T_m = 225^\circ\text{C}$). The former is a copolyester of 73 mol% p-hydroxybenzoic acid (HBA) and 27 mol% 2-hydroxy-6-naphthoic acid (HNA). The chemical structure of the latter has not yet been disclosed.

Most polymers are dielectrics which means that they are electrical insulators. Once a dielectric material is placed in an electric field that alternates at high frequency, the polar molecules within it will try to oscillate in accordance to the applied field generating heat through molecular friction. This is the principle of the dielectric heating in polymers which is a quick and uniform process. A microwave is an electromagnetic radiation in the frequency range of 1–300 GHz, capable of inducing dielectric heating and thus offers reasonable savings when compared to other types of heating in terms of energy and time. Lately, microwave heating and processing of materials has been the focus of intensive studies due to its potential applications to materials such as polymers, ceramics, and minerals. Its applications in an area of polymer technology are, for example, vulcanizing rubber, joining and welding plastic parts, polymerization, and the preparation of polymer foams. This work, therefore, applied this advanced heating technique to the in-situ composites for the first time and evaluate its advantages and drawbacks. In the near future, the use of such technique may find their way into industrial applications for the in-situ composites and the systems alike.