CHAPTER I

INTRODUCTION

"Barrier property" of materials is considered as key characteristic for practical applications, especially in packaging industry. In general, package plays a key role in retaining the product quality until it is used or expired, by protecting the product against the small molecules such as oxygen and moisture, which can cause product deterioration as well as to prevent the product from losing their components, taste and flavor.

It is well realized that, most of traditional high barrier packages are made of metal or glass. However, due to brittleness of the materials, packages have been used in a relatively thick form which leads to high cost of material and energy required in processing and also transportation. For this reason, these materials tend to be replaced by polymer. The advantages of polymer that make them widely use are light weight, flexible, strong, transparent, easy to shape into desired products both rigid and flexible forms. Processing polymer packages requires relatively low energy compared with producing metal and glass packages. This is especially in the case for thin polymer packages, such as film for pouch. In addition, light weight polymer packages with suitable design require smaller space and save transportation cost. Various types of polymer are commercially available and relatively inexpensive.

Nowadays, many high barrier polymers are available such as poly vinylidene chloride (PVDC), liquid crystalline polymer (LCP), ethylene-vinyl alcohol (EVOH) and polyamide or Nylon. Unfortunately, most high barrier polymers are relatively expensive and have some limitations in practice, For instance, Nylon and EVOH are highly sensitive to moisture. Barrier properties of these materials decrease when exposed to humid atmosphere. PVDC on the other hand, needs a rather complicated process for production due to its narrow range of processing temperature [1]. Many approaches are arisen in order to make a full use of these high barrier materials. Multilayer films and coated films are examples of some practical methods. The main idea of producing these multilayer films is to reduce the amount of high barrier polymer by combining these expensive materials with other cheaper commercial polymers and to utilize such combined advantages of the package components. For instance, PVDC is applied as a coating layer for plastic film. In some cases of multilayer films, high barrier polymers such as EVOH or Nylon are used as a middle layer of gas barrier while the outer or inner layers can be many types of polymers depending upon the requirements including printability or sealability. Polyolefin films, i.e. polyethylene (PE) and polypropylene (PP), are typically used for moisture barrier applications with required sealability.

Commonly, multilayer films can be produced by both co-extrusion and lamination. Although these processes are widely used but there are some drawbacks, in particular high cost of machine investment, as well as the need of expertise for such a complex process. Furthermore, when considering environmental concerns for multilayer films and coated films, their recycling difficulties have been realized a major limitation. Thus, polymer blend films appear to be alternatives in tackling recycling problems while at the same time polymer blends offer combined properties of high barrier and commodity materials at a reasonable cost. By utilizing conventional blending technique and film forming process, film with synergistic properties can be effectively achieved. Concept of producing high barrier film by blending is to create the tortuous path by adding high barrier polymer into the conventional one, this occurs in immiscible blend system [1- 3]. As shown in Figure 1.1, the longer distance a gas has to travel, the slower of permeation rate is. In other words, tortuous paths developed in an immiscible blend film can result in final high barrier property.

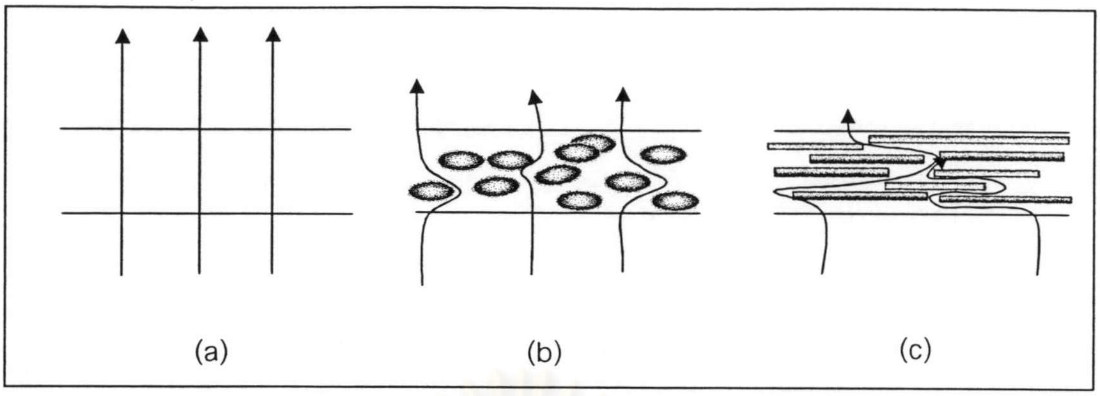

Figure 1.1 Tortuous path concept of polymer blend; (a) single polymer ,(b) polymer blend with droplet structure and ,(c) polymer blend with fibrous structure (and illustrate geometry of an impermeable phase, where arrow (⟶) represents gas's path) [1]

From the Figure 1.1, it is clearly seen that barrier property of polymer blend film significantly depends on the final morphology of the blend including size, shape, dispersion, and distribution of a high barrier impermeable phase. Morphology is generally controlled by rheological behavior of polymer components, blend composition, processing method and blending or forming conditions. Extensive works have been carried out on barrier property of blends. Nylon and EVOH blends were early investigated [4-9]; it was found that barrier property could be modestly improved when achieving droplet and fibrous structure. Barrier characteristics could also increase with increasing content of high barrier polymer component. The highest barrier property could be obtained from laminar structure in the films. However, both Nylon and EVOH sacrifice their barrier properties in humid condition. It is, therefore, proposed in this study that such a shortcoming of Nylon and EVOH can be overcome by utilizing liquid crystalline polymer (LCP), the outstanding engineering polymer with unique rheological property.

Previous studies on LCP blends mainly involved mechanical property improvement of thermoplastic blends containing LCP [10-16]. This is due to LCP's advantages in enhancing blends' properties through fiber forming "in-situ" or during processing, and in reducing viscosity of the overall blend systems. Blends of LCP with engineering plastics are widely examined. These include LCP blends with polycarbonate (PC), polybutylene terephthalate (PBT), polyethylene terephthalate (PET), and Nylon. Extensive studies have involved blends of LCP with engineering plastics because most available LCP's posses high melting point in a range of 280-320° C. Suitable match of processing temperature of LCP's and their blends' counterparts are required in order to achieve fiber reinforcing effect of LCP. Therefore, studies on LCP blends with other low melting polymer, in particular polyolefins have been relatively limited.

Recently, LCPs having low melting temperature of 200-225 °C have been produced. This makes processing LCPs with commodity polymers possible. Early studies on polyolefin blends containing LCPs have revealed that LCP can be incorporated into the polymer in fibrillar form under appropriate processing conditions [17-21]. Successful generation of reinforcing structure of LCP fibers in PE and/ or PP matrix results in enhancement of the blends' modulus and other mechanical properties. Apart from mechanical property improvement of the blends containing LCP, attentions have also been paid on their barrier characteristics. LCP has been considered a super barrier material to oxygen and water as compared to other commonly used barrier polymers such as PET, Nylon, and EVOH. Outstanding barrier property of LCP remains regardless of humidity level as apposed to inferior barrier performance of EVOH in high humidity condition. It is, therefore, interesting for several researchers to explore a possibility of producing high performance and high barrier flexible films by incorporating LCP into polyolefin and other polymer for packaging applications. Some previous work showed that improvement in both mechanical and barrier performances of PE blends containing 10 - 30 wt% of LCP could be obtained [22-24]. However, understanding of relationships between structure of the LCP blend and their barrier characteristics have not been clearly established and related information to this aspect in the literature is limited.

It is, therefore, the purpose of this study to investigate effects of blend composition, processing variables and LCP phase structure on barrier and mechanical properties of the blend between commonly used LDPE and low melting temperature LCP. LDPE is chosen as a matrix of interest because LDPE is a common polymer used in packaging. However, LDPE possess poor oxygen barrier and relatively low mechanical properties. In general, PE also offers several advantages such as processing ease, sealability, and low cost. If LDPE films' barrier and mechanical properties can be enhanced by incorporation of LCP while maintaining other desirable characteristics of LDPE, these LCP/LDPE blend films can be potential materials in many applications. Utilization of LDPE can be expanded from packaging to other industrial uses. It should also be noted that one possible solution to the cost concern when using LCP could be minimizing the content of LCP by producing effective LCP structure in thin PE films. These films should have balance properties between barrier and mechanical performances. In this study, LCP is incorporated into LDPE and blend matrix of LLDPE/LDPE by melt blending using extrusion technique. Study involves effects of processing variables towards blending and controlling structure of LCP/LDPE extruded films. Polarized light microscope (OM) and scanning electron microscope (SEM) are used for determining blends' and films' morphologies. Oxygen and water vapor transmission rates of the resulting films as well as tensile property are measured. Efforts are made in establishing the fundamental understandings of the relationships between properties and structure of PE films containing LCP. It is hoped that knowledge obtained from this work can serve as an effective tool in further development of producing polymer blend films with barrier tailoring property.