

CHAPTER I

INTRODUCTION

The polymer industry has been recently directed to the development of new polymeric materials obtained by blending two homogeneous polymers. The blending of polymers is a useful means of combining and improving the properties of already existing polymer in the development of new polymeric materials at reasonable cost and toxicology. To develop polymer blends with desirable properties, an in depth understanding of the following topics is needed

- Miscibility- Thermodynamics and phase behavior.
- Morphology – Control via interfacial properties and processing conditions.
- Blend compatibilization- Use of compatibilizer.

Many of polymer are miscible homogeneous system, such as polyethylene/polystyrene blends (PE/PS), or polycarbonate/polyethylene terephthalate blends (PC/PET). But most polymer blends consist of thermodynamically immiscible with each other and on mixing form multiphase morphologies. The structures obtained are usually unstable, and the mechanical properties of the blends are poor because of the lack of adhesion between the phases. The morphological features of an incompatible blend, such as the size of the dispersed phase domains and the adhesion at the interface, play an important role in determining its mechanical properties. Evidence in the literature suggests that the blend morphology can be controlled by manipulating the interfacial tension and the shear stress of the melt. However, the morphology and properties of polymer blends can be brought back to their original level by adding additional phase. This phase usually is called “compatibilizer”. The best known effect from compatibilizer is reduction of the interfacial tension in the melt. This cause is an emulsifying effect controlling and stabilizing the blend morphology and increasing the adhesion between the phases.

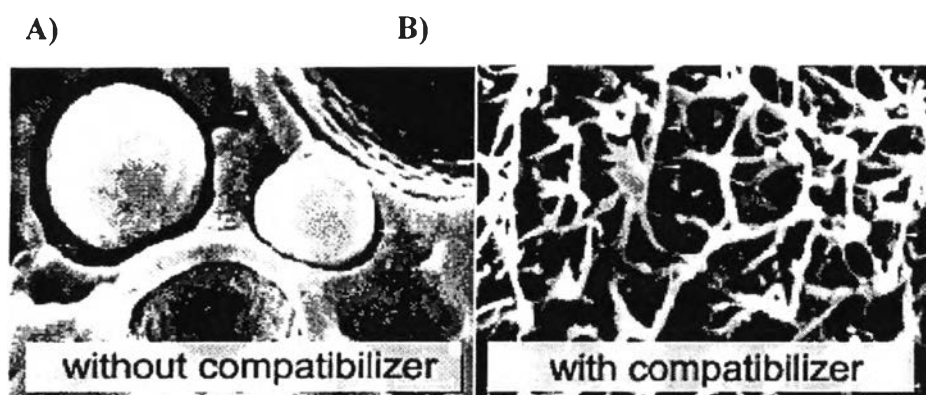


Figure 1.1 Scanning electron microscope for polymer blend. A) without compatibilizer. B) with compatibilizer.

In this research field it is necessary to know how the blend components interact, in order to have an idea of the expected properties. A lot of work has been reported on blends of Nylon with rubbers and polyolefin. The reported work has been dedicated to the study of Nylon6 with polyolefin, such as high-density polyethylene (HDPE), low-density polyethylene (LDPE), ethylene propylene rubber, and ethylene-based propylene diene monomer. All of these are basically ethylene-based polymer and the compatibilization has been achieved through use of copolymer or adducts of maleic anhydride (Armat and Moet, 1993), different acrylates such as polyethylene-graft-butylacrylate (Raval *et al.*, 1991) and polyethylene-methylacrylic acid isobutyl acrylate terpolymer (Willis and Favis, 1998). Use of commercial compatibilizers has been tried, and the observed change has been explained on the basis of possible interaction reaction between amine groups in Nylon6 and the carboxylic groups in the copolymers.

Polyamide (PA) is an important engineering thermoplastic having good wear, heat resistant, high strength, thermal stability and good barrier to oxygen and organic solvents. However, it has poor dimensional stability, high water absorption, and poor impact strength. It is therefore generally blended with polymer having high impact strength such as polyolefin to widen its application potentials. Polyethylene (PE) is one of the most suitable materials for blending with polyamide because of

improvement of the poor properties of polyamide and capitalize on the good properties of PE.

PA/PE blends are immiscible represent two phases morphology with poor blends due to the presence of polar group in the PA and the non-polar group ones of the PE. These blends exhibit properties that can be further modified using a suitable compatibilizer such as ethylene methacrylic acid copolymer (Scaffaro *et al.*), acrylates such as LDPE-g-butyl acrylate (Raval *et al.*,1991) and Ionomer such as Surlyn® ionomer (Fairley and Prud'Homme, 1987, Panita *et al.*, 2003).

The functionalization of polyethylene with a small amount of ionic group is a particular attractive way of compatibilizing polyamide with polyethylene because the amide group may interact with the ionomer via hydrogen bonding, ion-dipole interactions, or/and metal ion coordination during melt blending. The introduction of such specific interaction can improve compatibility and may promote miscibility of polyamide and polyethylene blends.

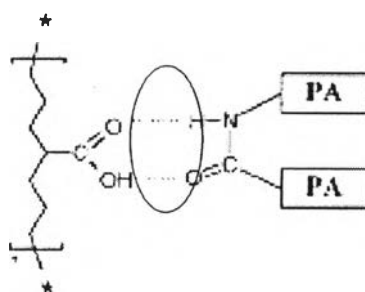


Figure1.2 Hydrogen bonding between poly(ethylene-co-acrylic acid) (PEAA) and polyamide6 (PA6).

Ionomers are the thermoplastic polymers. They contain both nonionic repeat units, and a small amount of ion containing repeat units (The ionic groups make up less than 15% of the polymer). Surlyn® is a commercial thermoplastic ionomer resin that was introduced by DuPont in the early 1960's. Surlyn® is the random copolymer poly(ethylene-co-methacrylic acid) (EMAA). The incorporation of methacrylic acid units can be neutralized with suitable cation, commonly Zinc (Zn^{2+}) or Sodium (Na^+). This ionomer is produced through the co-polymerization of

ethylene and methacrylic acid via high pressure free radical reaction, similar to that for the production of LDPE.

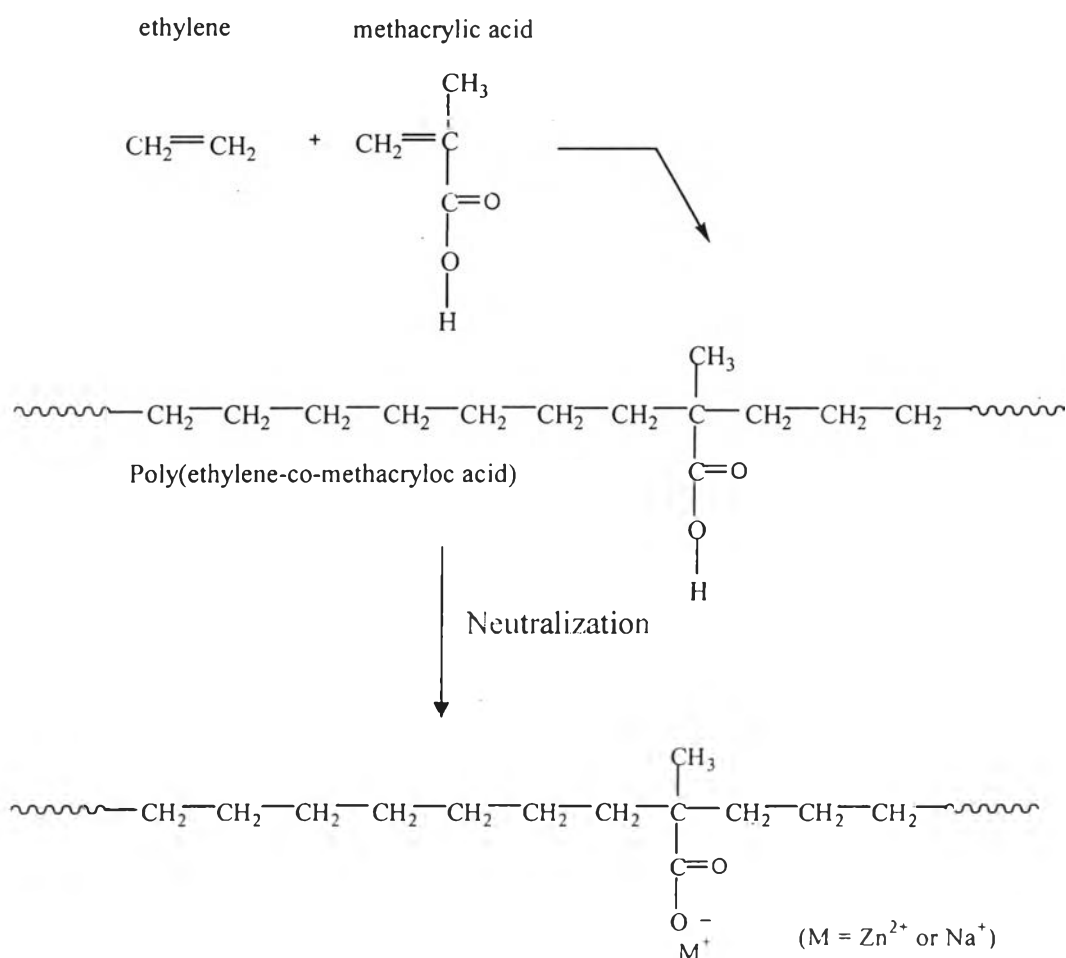
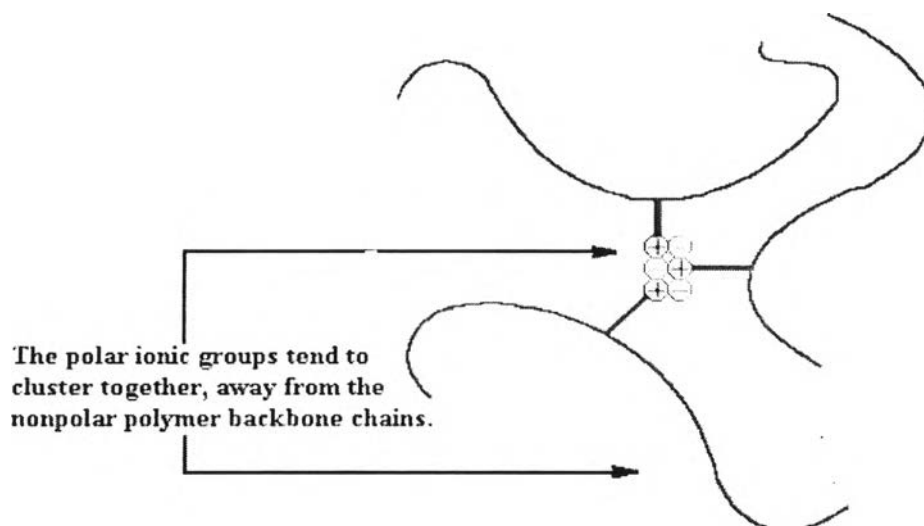


Figure 1.3 The structure of Surlyn® ionomer.

Surlyn® ionomer, the main chain is based on PE in which a small amount of acid comonomer is present. A few mol % ionic groups along the backbone has a tremendous effect upon the morphology and the properties of the polymer. The presence of the methacrylic acid units and the neutralized carboxylate anion/cation pairs provides sites for ionic interaction. Interaction between ion pairs, and the nonpolar nature of the backbone, will cause the ions to aggregate together which act as “**thermally reversible crosslinks**” (see Figure 1.4).



However, ionomers are not crosslinked polymers. When heated, the ionic groups will lose their attraction for each other and the chain will move around freely.

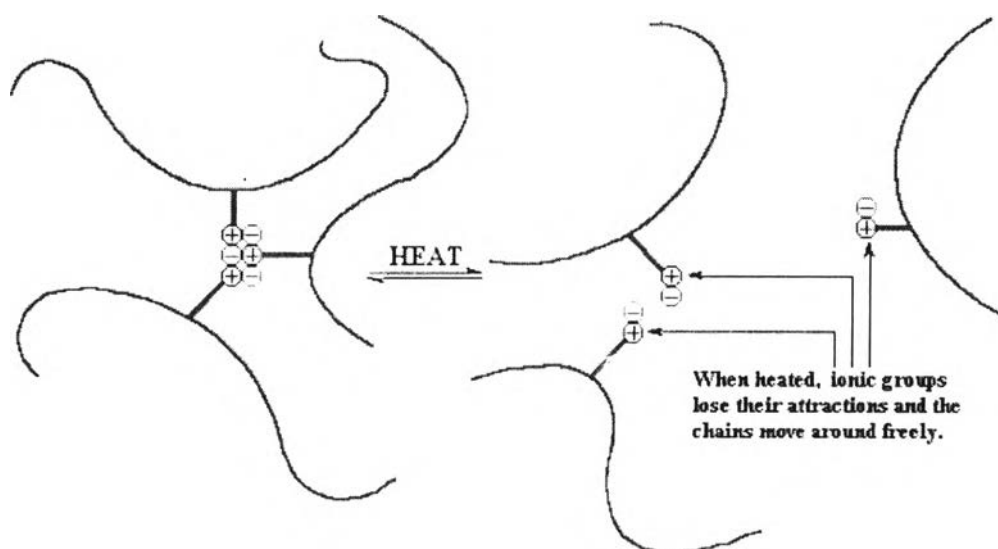


Figure1.4 Reversibility of the crosslinks of ionomers.

Surlyn® ionomer has an excellent heatsealability, maximum hot tack and it can be sealed through contaminants, and therefore it is used as a premium heatseal layer for packaging films, especially recommended for high speed packaging machines.

Ionomer based blends are interesting not only for their compatibilization efficiency which results from the strong intermolecular associations but also for the

substantial enhancement in physical properties that they bring about. Beside the thermal analysis, the dynamic mechanical and mechanical behavior is another important technique from which additional information can be obtained.

In previous studies have shown that sodium-neutralized ethylene-co-methacrylic acid ionomer is an effective compatibilizer in polyamide6/low density polyethylene blends. The addition of this ionomer to PA6/LDPE blends resulted in a significant decrease in the dispersed phase size and increase in thermal behavior of the resulting blends. The dispersed phase size obtained from this ionomer was smaller than the dispersed phase size of Zinc-neutralized ethylene-co-methacrylic acid ionomer.

The aim of this work is to study the effect of compatibilizer content of polyamide6/low density polyethylene blends using sodium-neutralized ionomer as a compatibilizer. Attention will be focused on the mechanical, dynamic mechanical behavior and morphology of the resulting blend systems.