สำนักงานวิทยทรัพยากร จุฬาลงกรณ์มหาวิทยาลัย

# CHAPTER I
# INTRODUCTION

By blending different polymers, new materials with desirable combination of properties can be developed. Most polymers are incompatible 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. However, the morphology and properties of such blends can be controlled by the introduction of a third component, a compatibilizer. The compatibilizer is usually a copolymer that is interfacially active and adsorbs at the interface between the matrix and dispersed phase, thus controlling and stabilizing the blend morphology and increasing the adhesion between the phases.

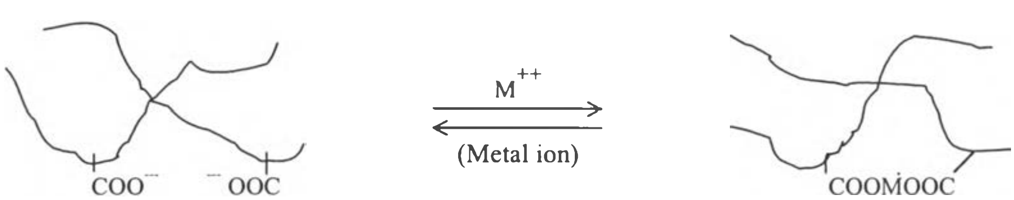
Polyamide (PA) is the most widely used engineering plastic because of its rigidity, thermal stability and good barrier to oxygen and organic solvents. But PA has limitations in its end use, e.g. it has low impact strength (particularly below its glass transition temperature), poor dimensional stability due to high moisture absorption, and difficulty in processing. Polyethylene (PE) is one of the most prevailing and suitable materials for packaging because of its easy processing, good resistance to moisture permeation, excellent chemical inertness, and low temperature flexibility. However, oxygen and many organic compounds have high permeability through PE. To improve the poor properties of PA and capitalize on the good properties of PE, blending of PA and PE is particularly attractive. However, PA and PE are incompatible and produce a phase-separated unstable morphology when blended together. To stabilize the PA/PE blends, many different compatibilizers have been experimentally studied, e.g. copolymers or adducts of maleic anhydride (Armat and Moet, 1993), different acrylates such as polyethylene-graft butylacrylate (Raval *et al.,* 1991), and polyethylene-methacrylic acid isobutyl acrylate terpolymer (Willis and Favis, 1988).

This work studied the use of zinc-neutralized ethylene-methacrylic acid (E-MAA) ionomer as a compatibilizer for blends of low-density polyethylene (LDPE) and polyamide 6 (PA 6). This type of ionomer, which is zinc neutralized, is marketed by DuPont under the trademark Surlyn®. Neutralization with zinc is preferred for many packaging applications as the zinc-neutralized ionomer has superior adhesion in coextrusion and foil coating. The effects of ionomer as compatibilizer for PA 6/LDPE blends were studied in terms of dynamic mechanical properties and thermal behavior over a range of compositions.

During melt blending, chemical reactions may take place between the amine end groups of PA and carboxyl groups present in the ionomer. In addition, the amide groups may interact with the ionomer via H-bonding, ion-dipole and /or metal-ion coordination. These chemical reactions and interactions would be expected to enhance the compatibility of PA and ionomer. Thus, this work also focused on blending PA 6 with ionomer and study the morphology, mechanical properties, rheological properties, thermal behavior, X-ray diffraction pattern and interactions of the binary PA 6/ionomer blends.

**Ionomers**

The general term "ionomer" denotes a thermoplastic polymer containing a small mole fraction of ionic groups. In the most common commercial example of these types of materials, the main polymer chain is based on PE in which a small amount of acid comonomer is present. Ionic side groups (anionic) combine with oppositely charged metallic ions (cationic) to form "labile crosslinks". The ionic crosslinks break apart at high temperature (processing temperature). Thus, the material flows like conventional PE when molten (however, at a much higher viscosity) but has elastic properties characteristic of lightly crosslinked thermosets (e.g. elastomers) when solid, i.e. at room temperature. Ionomers are said to have thermally reversible cross-links as displayed schematically in Figure 1.1




- Molten State
- Separate polymer chains

- Solid state
- Crosslinked chains

**Figure 1.1** Characteristics of ionomer in molten and solid states.

Surlyn® ionomers are derived from ethylene and methacrylic acid comonomers. The carboxylic acid side groups are partially neutralized by Group I or II metal ions such as sodium, potassium, magnesium and zinc ions. Commercial grades of Surlyn® are available in approximately 25 different grades. They vary in ion type, molecular weight, crystallinity, and acid content. In this work, zinc-neutralized E-MAA ionomer, Surlyn® grades 9020 and 9650, were used. The structure of these ionomers is shown in Figure 1.2.

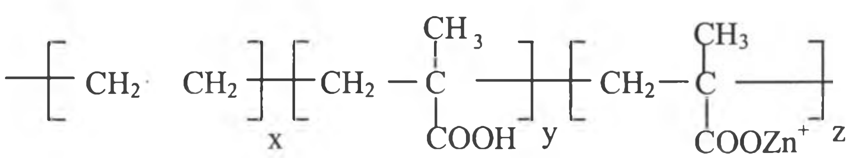


**Figure 1.2** Structure of zinc-neutralized ethylene-methacrylic acid (E-MAA) ionomer.

Because the ionic crosslinks are thermally broken at normal processing temperatures, i.e. 175-290 °C, Surlyn® resins can be processed on standard molding and extrusion equipment.

Surlyn® resins incorporate many of the performance features of the ethylene-based homopolymer such as chemical resistance, melting range, density, and basic processing characteristics. However, Surlyn® resin performance is significantly enhanced in areas such as:

- Low temperature impact toughness
- Abrasion resistance
- Chemical resistance
- Transparency
- Melt strength

Other important commercial ionomers include Nafion® sulfonated tetrafluorethylene ionomer and Nafion® sulfonated polystyrene ionomer, which are used as a membrane separator and viscosity modifier respectively. Nafion® is a registered trademark of DuPont Co., Ltd.