# Compatibilization of PET/LDPE Blends

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## Introduction

The steady growth in the use of plastic materials in packaging applications has caused an increasing concern about the environment and the problem of solid waste disposal. Therefore, the recycling of plastics is the very important problem, which must be solved technically and environmentally [1]. It is technically feasible to recycle, recover and reuse all of the plastics discarded, but economics limit the degree of recycling at this time.

Recycling of poly (ethylene terephthalate) (PET) has been well investigated because PET can be easily collected from the wastes in the unmixed state and thus it has great advantage. Many approaches, which include chemical treatment methods such as methanolysis and hydrolysis have been developed and commercialized successfully. However, if we consider plastic bottles are made from several polymers it is also important to develop new method to recycle mixed plastics of PET maintaining an acceptable level of properties and cost. Polymer blends may offer an alternative for the purpose. They also alleviate problems accompanied by chemical treatment methods, which require another expense and the environmental pollution. Many researchers have studied on the recycling of polymers using polymer blending technology [2].

The study of PET/polyolefin (PO) blends is of considerable technological importance. Since PET/PO blends are incompatible, research efforts have been directed towards PET modification or compatibilization of the blends. Generally, modified polyethylenes (m-PE's) are widely known to be effective in compatibilization of PET/PO blends [3,4]. Functional moiety such as epoxy or maleic anhydride groups is required to react with chemical groups in PET. In this study, as the first part of the compatibilization of PET/PE blends, we investigate the effects of the type and content of functional groups in m-PE's on their compatibilizing performance and the crystallization behavior of PET.

## Experimental

The characteristics of the polymers used in this study are listed in Table 1. All polymers are commercially available. Expect for Aclyn 285, which was in powder form, all polymers were provided as pellets. Before melt mixing, PET was dried in convection oven at 140 ℃ for 4 hours and 100 ℃ overnight. LDPE and compatibilizers were vacuum dried at

temperature of 90 and 60 ℃ for 20 hours, respectively.

The dried materials were melt-mixed using a Haake Rheomix 3000 batch mixer at 270 ℃ for 10 minutes. The rotor speed was 50 rpm. Binary blend of PET/m-PE and ternary blends of PET/LDPE/m-PE were prepared. The blend ratios of the binary and ternary blends were 90/10 and 70/20/10 wt %, respectively; PET acts as matrix. After mixing, the blends were quenched in water and then dried.

Table 1. The characteristics of polymers used in this study

| Materials | Source | $T_m$ (℃) | Remarks |
| --- | --- | --- | --- |
| PET | Sam Yang Co. | 257.7 | IV = 0.807; DEG = 1.4 mol % |
| LDPE | Dow Chem. | 115 | |
| Surlyn 8920 | DuPont | 91 | Na salt of EMA copolymer; MI = 0.9 g/min |
| Surlyn 9730 | DuPont | 97 | Zn salt of EMA; MI = 1.6 |
| Primacor 3460 | Dow Chem. | 96 | EAA copolymer; AA content = 9.5 %; MI = 20 |
| Polybond 1009 | Uniroyal Chem. | 133 | EAA; AA content = 6 %, |
| Polybond 3009 | Uniroyal Chem. | 132 | Et-MAH copolymer; MAH content = 1 % |
| PE-GMA 8 | Elf Atochem. | 110 | Et-GMA copolymer; GMA content = 8 % |
| PE-GMA 25 | Elf Atochem. | 87 | Et-GMA copolymer; GMA content = 25 % |
| Aclyn 285 | Allied Signal | 82 | Sodium salt of EAA |

EMA = ethylene-methacrylic acid; EAA = ethylene-acrylic acid; MAH = maleic anhydride; GMA = glycidyl methacrylate copolymer

Thermal analysis was performed on Perkin-Elmer DSC-7 differential scanning calorimeter (DSC). Nitrogen was purged through the DSC to prevent oxidative degradation of blends. In PET/compatibilizer blends, isothermal crystallization was performed whether functional moiety in m-PE affects the crystallization of PET or not. Samples were first heated from room temperature to 280 ℃ at a rate of 20 ℃/min, held at final temperature for 3 minutes and then quenching to 220 ℃. At this temperature, isothermal crystallization was performed for 30 minutes.

Specimens for impact and tensile tests were injection-molded with Mini Max molder (Bau Technology Co.) at 270 ℃ after 5 minutes of melting time. Tensile test was performed according to ASTM D638 at room temperature using a Shimadzu Autograph AGS-500D tensile tester. The crosshead speed was 20 mm/min.

The morphology of blends was characterized using a JEOL JSM 5400 scanning electron

microscope (SEM). Blend samples were fractured at liquid nitrogen temperature. To enhance the contrast fractured surfaces were etched with 10 % solution of KOH in ethanol at room temperature for 24 hours.


## Results and Discussion

Figure 1 shows the torque changes of PET/m-PE binary blends during melt mixing. The blends with PE-GMA 8 and 25 have a relative higher torque than others. This may be the result of chemical reaction between GMA and carboxyl or hydroxyl terminal groups in PET.
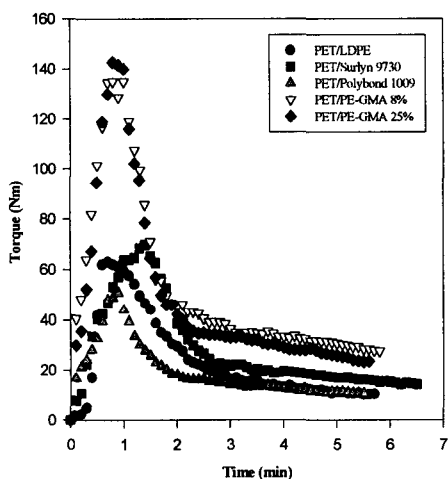


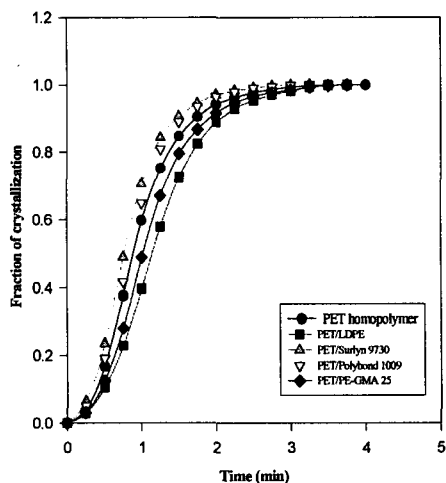Figure 1. Torque changes during mixing of PET/modified PE 90/10 (by weight) blends.



Figure 2. Fraction of isothermal crystallization of PET in blends as a function of time.

Thermal properties of blends obtained from DSC are shown in Table 2. Half time of crystallization is also shown in Table 2 [5]. The results shown are typical of incompatible blends. Although chemical or physical reactions occur between functional moiety in m-PE and PET, they do not change the thermal properties significantly. Figure 2 shows the fraction of crystallization of PET in blends as a function of time. During isothermal crystallization at 220 °C for 30 minutes, PET forms the crystal in short time. Although Surlyn 9730 appears to accelerate crystallization of PET, most m-PE's do not affect it. To assess whether m-PE's act as nucleating agents or not, more elaborate work is needed [6].

**Table 2.** Thermal properties of PET and its blends with modified PE's

| Blend | $T_{m, PET}$ | $\Delta H_{f, PET}$ | $T_{m, m\text{-}PE}$ | $\Delta H_{f, m\text{-}PE}$ | $t_{1/2}$[a] (sec) |
|---|---|---|---|---|---|
| PET | 257.67 | 44.87 | - | - | |
| LDPE | 255.01 | 41.88 (46.53)[b] | 108.61 | 3.81 | 69 |
| PET/Surlyn 8920 | 252.56 | 32.70 (36.33) | 83.60 | 1.06 | - |
| PET/Surlyn 9730 | - | - | - | - | 46 |
| PET/Polybond 1009 | 254.37 | 37.69 (41.88) | 125.11 | 9.75 | 50 |
| PET/Polybond 3009 | 254.70 | 44.39 (49.32) | 124.65 | 11.53 | 68 |
| PET/PE-GMA 8 | 255.07 | 45.99 (51.10) | 89.40 | 2.54 | 83 |
| PET/PE-GMA 25 | 255.39 | 43.91 (48.79) | - | - | 61 |

[a] Half time of crystallization.
[b] The value in parentheses is the normalized value.

**Reference**

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