Morphology and Chemical Resistance of Poly(ethylene terephthalate)/ Polycarbonate Blends: Effect of Blend Compositions

Nurul Ain Jamaludin[1], Azman Hassan[2*], Norhayani Othman[3]

[1, 2, 3] Department of Polymer Engineering, Faculty of Chemical Engineering, University Teknologi Malaysia, Skudai, Johor, Malaysia

* corresponding author: azmanh@cheme.utm.my

Abstract

Blends of poly(ethylene terephthalate) (PET) and polycarbonate (PC) were prepared in different ratios by melt blending technique. The process was carried out through a twin screw extruder followed by injection molding. The morphological and chemical resistance of the PET/PC blends were studied. The scanning electron microscopy showed that the interfacial adhesion for 70PET/30PC blends has improved as indicated by the partial miscibility between the PET and PC. The chemical resistance of PET/PC blends to acetone increased with increasing PET content.

Keywords. Blends; Chemical Resistance; Polycarbonate; Poly(ethylene terephthalate);

1 Introduction

Poly(ethylene terephthalate) (PET) is a thermoplastic polymer resin, and it exists either as an amorphous or semi crystalline polymer depending on its processing and thermal history [1]. PET is one of the most important commodity thermoplastics due to its high performance, low cost, and recyclability [2]. Besides blow molded bottles, it is also used as extruded films, sheets, monofilaments, and also for containers [3]. These special properties of PET are the basis for its broad application. Despite these advantages, however, PET has shortcoming of very low impact strength and low glass transition temperature (T_g) that have limited its use in certain application. For example, PET containers shrink or distort above 80°C. PET was generally blended with other high performance engineering plastics such as polycarbonate (PC) in order to upgrade the use of PET [4].

Blends of PET with PC would be a good approach to attain the desired properties such as better impact properties since PC has high impact strength [4]. PC is important engineering thermoplastic and can contribute towards improvements in strength, dimensional stability, heat distortion temperature and impact resistance of the blends [5] However, PC is characterized by poor solvent resistance which has severely limited its applications in chemical environment [6]. On the other hand PET provides excellent chemical resistance [7]. The miscibility of this blend system, which plays an important role in property modification, has been studied extensively.

The studies on PET/PC blends have been studied over three decades [8, 9]. From their studies, it was found that the PET/PC blend formed homogenous phase for composition above 70 wt% of PET. By using differential scanning calorimetry, Fourier transforms infrared spectroscopy and phase contrast microscopy, Suzuki *et al*. [10] have reported that, PET/PC was immiscible over the whole range. Wang *et al*. [11] have reported that PET/PC blends are partially miscible from 10 to 90% composition.

The previous investigations of the PET/PC blends have focused on morphology phase, thermal behavior [8], [12] and mechanical properties [4], [9]. In this present study, the effect of blend compositions on morphological properties and chemical resistance of PET/PC blends to the acetone were investigated. No similar study has been reported in the literature.

2 Methods

Materials. PET (EM 100) used was supplied by Recron Malaysia Sdn. Bhd. It had an intrinsic viscosity of 0.78-0.84 dL/g, melting temperature of 245-255°C (DSC, ASTM E 928) and molecular weights of about 30,000 g/mole. PC used was Panlite L-1225Y which was supplied by Teijin Chemical, with melt flow index at 300°C of 11.0cm^3/10 min and density of 1.20 g/cm^3.

Melt processing. PET and PC pellets were dried for more than 8 h at 110°C in oven. A detailed formulation of the prepared nanocomposites is shown in Table 1.

Table 1. Composition of the PET/PC blends

Composition	PET (wt%)	PC (wt%)
PET	100	0
90PET/10PC	90	10
80PET/20PC	80	20
70PET/30PC	70	30
60PET/40PC	60	40
50PET/50PC	50	50
PC	0	100

PET and PC and HNT were manually premixed in a container then feed into a counter-rotating twin screw extruder Plastic Corder, PL 2000. The extruder temperatures were set at 220°C (zone 1), 240°C (zone 2), 245°C (zone 3) and 250°C (die). The screw speed was set at 25 rpm. The extruded products were cooled and cut into pellet form by using pelletizer. The pellets were dried at 110°C for 12 h before injection using an injection molding machine (JSW 100Ton). The temperatures from the hopper to the nozzle were from 220 to 250°C.

Scanning electron microscopy. The scanning electron microscope (SEM, Philips XL40) was used to investigate the interface morphologies and tensile fracture specimens were used for morphological observations. The samples were coated with a thin layer of gold before the observations.

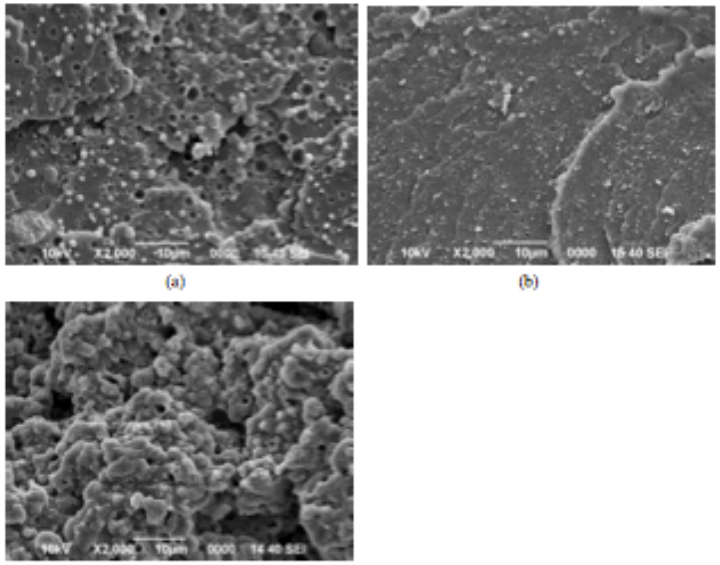
Chemical resistance. The testing was carried out according to ASTM D543-87. The specimens were immersed in acetone. After the immersion, the specimens were rinsed, wiped and weighed. For each specimen, the percentage of mass difference was calculated by the following Equation 1.

$$(m_2 - m_1)/m_1 \times 100 \qquad \text{(Equation 1)}$$

Where;
m_1 = weight before immersion
m_2 = weight after immersion

3 Results and Discussion

Morphological properties. Figure 1 shows the SEM image of PET/PC blends taken from the fractured surface of the tensile test. For blends containing 10 wt% of PC (Figure 1(a)), it can be seen that the blend exhibited inhomogeneous fracture surface and the PC phase appears as spherical inclusions in the PET phase matrix. In addition, the microvoids surrounding the PC droplets indicate that the interfacial adhesion is weak. Similar study reported by Kong and Hay [4] on PET/PC blends. They found that at lower blend compositions, spherical PC particles were distributed throughout PET matrix. Incorporation of 30 wt % of PC content clearly reduced the particle size due to improve of the interfacial adhesion between the PC and PET matrix. The smaller phases could be seen as shown in Figure 1(b). The partial miscibility has improved the interfacial adhesion between the PET and PC. Similar result was also reported by Frounchi *et al*. [6]. They found that the finer size of PC domains in PET/PC blends was attributed to the partial miscibility of PET and PC. Comparatively, the morphology for 50 wt% of PC in Figure 1(c) shows that a co-continuous morphology. A similar observation as reported earlier by Kong and Hay [4], where the co-continuous morphology was observed when 50PET/50PC blend were used.



(a) (b)

(c)

Figure 1. SEM images of tensile fractured surfaces of PET/PC blends (a) 90PET/10PC (b) 70PET/30PC
(c) 50PET/50PC

Chemical resistance. Figure 2 and 3 shows the swelling effect of PET/PC blend samples after immersion in acetone for 16 days. This swelling effect is represented by the percentage of weight increase after the immersion.

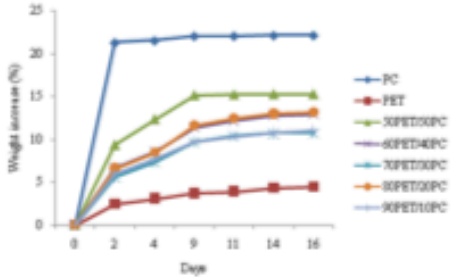


Figure 2. The weight increase of PET/PC blends after immersion in acetone

Figure 3. PET/PC blends samples after immersion in acetone

It can be seen that the weight change occurred for pure PC about 21.3% weight even after 2 days immersion in acetone. This result revealed that PC has poor resistance to acetone [7]. The weight change in pure PET after immersion in acetone was only minimal 4.5%. This phenomenon indicates

that PET has a good resistance to acetone. It can be seen that the weight change slightly occurred for all blends after 2 days and started to remain constant at day 9. The results also shows that chemical resistance of the PET/PC blends increased with increasing PET content. This is due to the increasing ratio of PET in the blends, which has better resistance to acetone than PC. It is interesting to note that 70PET/30PC blend almost has the similar weight changes values as compared to 90PET/10PC whereby the weight increased by 10.8% after 16 days. This enhancement was attributed to the improved interfacial adhesion between the PET and PC phases for 70PET/30PC as shown in Figure 1(b).

4 Conclusion

The morphology of PET/PC blends was characterized and the result showed that PET/PC blends formed partial miscibility for 70PET/30PC blends. The chemical resistance of the PET/PC blends to acetone increased with increasing PET content since PET has good chemical resistance compared to the PC. Interestingly, 70PET/30PC showed similar weight changes to 90PET/10PC which indicates that the chemical resistance of both blends is the same. This is due to the good miscibility between the PET and PC phases at 70PET/30PC blends.

ACKNOWLEDGMENT

The authors would like to express their appreciation for the support of the sponsors with Project No Q.J130000.2544.07H18.

References

1. Baliga, S. and Wong, W. T. "Depolymerization of Poly (ethylene terephthalate) Recycled from Post-Consumer Soft-Drink Bottles," Journal of Polymer Science: Part A: Polymer Chemistry, vol. 27, pp. 2071-2082, 1989.
2. Shukla, S. K. and Kulkarni, K. S. "Depolymerization of Poly (ethylene terephthalate) Waste," Journal of Applied Polymer Science, vol. 85, pp. 1765-1770, 2002.
3. Oromiehie, A. and Mamizadeh, A. "Recycling PET Beverage Bottles and Improving Properties," Polymer International, vol. 53, pp. 728-732, 2004.
4. Kong, Y. and Hay, J. N. "Miscibility and Crystallization Behaviour of Poly(ethylene Terephthalate)/Polycarbonate Blends, " Polymer, vol. 43, pp. 1805-1811, 2002.
5. Charles, A. H. *Modern Plastics Handbook*. Maryland.: McGraw-Hill, Inc, 2000.
6. Frounchi, M., Mehrabzadeh, M., and Mohseni, S. S. "Phase Morphology of Polyblends of Amorphous Polycarbonate and Semi-crystalline Polyethylene Terephthalate," Iranian Polymer Journal, vol. 11, pp. 151-157, 2002.
7. Baker, A. M. and Mead, J. L. *Thermplastics*. New York.: McGraw-Hill, 2006.
8. Nassar, T. R., Paul, D. R., and Barlow, J. W. "Polyester-Polycarbonate Blends. II. Poly(ethylene Terephthalate), " Journal of Applied Polymer Science, vol. 23, pp. 85-99, 1979.
9. Murff, S. R., Barlow, J. W., and Paul, D. R. "Thermal and Mechanical Behavior of Polycarbonate-Poly(ethylene Terephthalate) Blends," Journal of Applied Polymer Science, vol. 29, pp. 3231-3240, 1984.
10. Suzuki, T., Tanaka, H., and Nishi, T. "Miscibility and Transesterification in Bispbenol A Polycarbonate/Poly (ethylene terephthalate) Blends," Polymer, vol. 30, pp. 1287-1297, 1989.
11. Wang, L., Huang, Z., Hong, T., and Porter, R. S. "The Compatibility and Transesterification for Blends of Polyethylene terephthalate)/Poly(bisphenol-A carbonate)," Journal of Macromolecular Science: Physics, vol. B29, pp. 155–169, 1990.
12. Kim, W. N. and Burns, C. M. "Compatibility Studies of Blends of Polycarbonate and Poly(ethylene terephthalate), " Journal of Polymer Science: Part B: Polymer Physics, vol. 28, pp. 1409-1429, 1990.