Effect of PS-g-MAH Content on ABS/PC Composites

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Abstract. Acrylonitrile–Butadiene–Styrene (ABS) is a common plastic which used in many fields with two-phase system. Polycarbonate (PC) is a high-performance amorphous engineering thermoplastics. ABS/PC composites were researched in many academic papers and used in many fields. Polystyrene(PS) grafted with maleic anhydride (MAH) (PS-g-MAH) on ABS/PC composites is studied in this article. The tensile strength and elongation at break of ABS/PC blends have the maximum value when the content of PS-g-MAH is 3%. Tg of ABS in blends increase with the content of PS-g-MAH, which maybe induced by the increase of ABS/PC interface compatibility. From the photo of SEM, the addition of PS-g-MAH improves the compatibility of the interface of the two phases, leading to an increasing trend in the size of PC particles.

1. Introduction

Acrylonitrile–Butadiene–Styrene (ABS) is a popular plastic in industrial as well as commodity applications and being used in many fields like defence, aerospace, automobile, electrical, computer and telecommunications among the synthetic thermoplastics materials. ABS plastics are two-phase systems, and it is a hard and tough thermoplastic with good impact strength and surface gloss. Polycarbonate (PC) is a resin in which groups of dihydric or polyhydric phenols are linked through carbonate groups. PC is a high-performance amorphous engineering thermoplastics with an exceptionally high impact strength, clarity, heat resistance, dimensional stability, and a good electric property. The process ability of PC is rather difficult because its high melt viscosity hinders the fluidity of PC, and the residual stress resulting from processing causes fractures. To improve these problems, new polymer blends and alloys have been developed. ABS, PC and their alloys are widely used in automotive industry, computer and equipment housings. ABS/PC can be used to produce products with various physical properties and effective functions. Fillers modify the existing physicochemical characteristics but also invariably reduce cost, improve workability during processing, and develop new properties not present in the original resin [1-4].

PC / ABS blends have been investigated with respect to compatibility and mechanical behaviour aspects, processing conditions have a stronger effect on the phase morphology. The phase morphology of PC / ABS blends can be significantly affected by its processing conditions. A synergistic effect was observed for modulus of elasticity upon the addition of PC in ABS [5-7]. A compatibilizer named acrylonitrile – butadiene–styrene copolymer (ABS) grafted with maleic anhydride (MAH) (ABS-g-MAH) have good influence on the mechanical properties, and could improve the compatibility of the ABS/PC alloy significantly[8-10].
A compatibilizer named polystyrene (PS) grafted with maleic anhydride (MAH) (PS-g-MAH) was used in this article to improve the performance of ABS/PC alloy. The tensile strength, thermal property and micrograph of the samples were studied.

2. Materials

ABS, Basf co., LTD. PC, Basf co., LTD. PS-g-MAH, Xuzhou kebao experiment instrument co., LTD. Material proportions were listed in Table 1.

Table 1 Material proportions

| Number | ABS | PC  | PS-g-MAH |
|--------|-----|-----|----------|
| 1      | 100 | 40  | 0        |
| 2      | 100 | 40  | 3        |
| 3      | 100 | 40  | 6        |
| 4      | 100 | 40  | 9        |
| 5      | 100 | 40  | 12       |

2.1. Blends and sample preparation

2.1.1 Drying. ABS and PC were dried in an oven to remove absorbed water. The drying conditions were shown in Table 2.

Table 2 Drying conditions

| Material | Drying temperature(℃) | Drying time(hours) |
|----------|------------------------|--------------------|
| ABS      | 80                     | 12                 |
| PC       | 120                    | 6                  |

2.1.2 Blending and injection moulding. ABS/PC composites were prepared by melt mixing in a co-rotating twin-screw extruder, operating at screw speed of 210rpm with a temperature ranging from 190℃ to 220℃ which depending on the mixture composition. Then the particles of the blends were obtained from a knife pelletizer. ABS/PC blends were dried in a vacuum oven at 80℃ for 6h, and injected from injection moulding machine with a temperature ranging 220℃ to 240℃.

2.2. Characterization

2.2.1 Test of mechanical properties. The tensile strength was tested by ETM104C electronic universal testing machine. Five samples of each composite were tested.

2.2.2 Test of glass transition temperature (Tg). Glass transition temperature (Tg) were tested by differential scanning calorimeter (DSC) (Perkin–Elmer DSC6000).

2.3. Morphology

The morphology of ABS/PC blends were tested by INSPECT S50 scanning electron microscopy (SEM) after the composites were covered with a thin layer of gold.

3. Results and discussion

3.1 Tensile properties

Figure 1 shows the tensile strength and the elongation at break for different contents of PS-g-MAH. The tensile strength and elongation at break of ABS/PC blends tend to increase first and then decrease...
with the addition of PS-g-MAH. The maximum value is 45.12MPa, 94% when the content of PS-g-MAH is 3%. The carboxyl group in PS-g-MAH can increase the compatibility between ABS and PC interface. There is an excellent compatibility between PS-g-MAH and ABS, which induce the strength of ABS/PC blends increases. However, the tensile strength decreased as the content of PS-g-MAH continued to increase. That may be induced by the excessive content of PS-g-MAH, which has become a three-phase component of ABS/PC/PS rather than just a compatibilizer. PS and PC are incompatible phases with each other, which may reduce tensile properties.

(a) The tensile strength of ABS/PC blends (b) The elongation at break of ABS/PC blends

Figure 1. The tensile properties of ABS/PC blends with different content of PS-g-MAH

3.2 Thermal property
Glass transition temperature (Tg) of ABS in blends are shown in figure 2. It can be seen that Tg of ABS shift with the increase of PS-g-MAH. Tg of ABS reaches 104.35$^\circ$C when the content of PS-g-MAH reaches 12%. There are two reasons for the increase of the glass transition temperature of ABS. First, the addition of PS-g-MAH increases the interface compatibility of ABS and PC, then decline the interface energy. Second, the increase of PS-g-MAH content will increase the proportion of PS components in ABS, which could be change the glass transition temperature of ABS in blends. That maybe induced by the increase of ABS/PC interface compatibility.

Figure 2. Tg of ABS in ABS/PC blends with different content of PS-g-MAH
3.3 Morphology

The morphology of ABS/PC blends are shown in figure 3. It can be clearly seen that ABS and PC are incompatible phases. And PC is dispersed in the ABS matrix evenly in globular shape. The addition of PS-g-MAH cannot integrate ABS and PC perfectly. We also observed that the size of PC particles dispersed in ABS matrix gradually increased with the increase of PS-g-MAH content from figure 3, table 3. This may be because the addition of carboxyl groups in maleic anhydride improves the interface compatibility of PC and ABS and reduces the interface energy.

Figure 3. The morphology of ABS/PC blends with different content of PS-g-MAH 1.0phr, 2.3phr, 3.6phr, 4.9phr, 5.12phr
Table 3 Diameter of PC particle

| The content of PS-g-MAH | Diameter of PC particle |
|------------------------|-------------------------|
| 0                      | 1.07                    |
| 3                      | 1.34                    |
| 6                      | 1.46                    |
| 9                      | 1.73                    |
| 12                     | 1.81                    |

4. Conclusion
The tensile strength and elongation at break of ABS/PC blends increase first and then decrease with the addition of PS-g-MAH. The maximum value occurs when the content of PS-g-MAH is 3%.

Tg of ABS increase with the content of PS-g-MAH, that may be because PS-g-MAH improve the interface compatibility of ABS and PC, then reduce the interface energy.

ABS and PC are incompatible phases, the addition of PS-g-MAH improves the compatibility of the interface of the two phases, leading to an increasing trend in the size of PC particles.

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