

Morphology and Thermal and Mechanical Properties of PBT/HIPS and PBT/HIPS-G-GMA Blends

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ABSTRACT: The modification of high-impact polystyrene (HIPS) was accomplished by melt-grafting glycidyl methacrylate (GMA) on its molecular chains. Fourier transform infrared spectroscopy and electron spectroscopy for chemical analysis were used to characterize the formation of HIPS-g-GMA copolymers. The content of GMA in HIPS-g-GMA copolymer was determined by using the titration method. The effect of the concentrations of GMA and dicumyl peroxide on the degree of grafting was studied. A total of 1.9% of GMA can be grafted on HIPS. HIPS-g-GMA was used to prepare binary blends with poly(butylene terephthalate) (PBT), and the evidence of reactions between the grafting copolymer and PBT in the blends was confirmed by scanning electron microscopy (SEM), dynamic mechanical analysis, and its mechanical properties. The SEM result showed that the domain size in PBT/HIPS-g-GMA blends was reduced significantly compared with that in PBT/HIPS blends; moreover, the improved strength was measured in PBT/HIPS-g-GMA blends and results from good interfacial adhesion. The reaction between ester groups of PBT and epoxy groups of HIPS-g-GMA can depress crystallinity and the crystal perfection of PBT. © 2002 Wiley Periodicals, Inc. *J Appl Polym Sci* 85: 2600–2608, 2002

Key words: HIPS/PBT blend; HIPS-g-GMA copolymer; morphology; thermal properties; dynamic mechanical properties; interfaces

INTRODUCTION

Polymer blending has acted an important role in the production of new commercial plastic materials to achieve cost/performance balances in the past decades. Except for a few polymer pairs that are known to be thermodynamically miscible, most polymer pairs are immiscible. Nevertheless, immiscible systems are actually desirable because components in a blend may retain their own properties. For a typical immiscible polyblending system, a satisfactory physicomechanical behavior depends on having the proper interfacial tension to generate a small phase size and a strong

interfacial adhesion to transfer the applied force effectively between component phases.¹ Methods to reduce interfacial tension and improve phase adhesion between immiscible components have been investigated and developed in the past 2 decades. Many articles^{2–6} reported that the presence of a block or graft copolymer with an appropriate chemical structure could provide a lowering of the interfacial energy and improvement of the interfacial adhesion between two phases. Therefore, a small domain size and a homogenous distribution of domains may be detected in these blending systems.

Recently, the *in situ*-formed compatibilizers in polymer blends have attracted great attention as alternatives to replace the conventional block or graft copolymers. Glycidyl methacrylate (GMA)-containing copolymers have been the most often

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used reactive compatibilizers.⁷⁻¹⁰ This approach is especially effective for polymers possessing terminal functional groups, such as polyesters or polyamides (PAs). The *in situ* reaction occurs during melt processing to form block or graft copolymers at interfaces. These *in situ*-formed copolymers can reduce the interfacial tension at a molten state; thus, the physicochemical behavior of a polyblend can be improved substantially.

Both high-impact polystyrene (HIPS) and poly(butylene terephthalate) (PBT) are commodity polymers that possess unique properties individually. PBT has been classified as a major engineering thermoplastic with excellent properties, such as tensile, abrasion, chemical resistance, and electrical insulation. HIPS has a low price but is a tough thermoplastic with relatively poor solvent resistance. A combination of PBT and HIPS would be ideal to produce a property-balanced blend product. In practice, however, it is difficult to obtain good performance because PBT and HIPS are immiscible. Although many studies on the compatibility of immiscible blends have been reported, such as on the systems of PBT/PS,¹¹⁻¹³ PBT/ABS,¹⁴⁻¹⁵ PP/HIPS,¹⁶ and PBT/LDPE,¹⁷ studies on the preparation of functionalized HIPS via melt grafting of GMA on to HIPS and the effect on PBT blends have not yet been reported.

In this study, we attempted to graft GMA on HIPS through reactive processing and to investigate the effect of an *in situ*-formed compatibilizer, HIPS-g-GMA, on the final morphology and mechanical properties of the binary blend of PBT/HIPS-g-GMA. Note that the epoxy group in HIPS-g-GMA can react with the carboxyl and hydroxyl at the chain in PBT, and then the physical and chemical interactions across the phase boundaries will control the overall performance of the binary blends. A series of blends of PBT/HIPS-g-GMA with excellent performance can be conducted by using the compatibilizer.

EXPERIMENTAL

Material

HIPS used in this study was a commercial product (492-J) manufactured by Yanshan Petrochemical Co. (Beijing, China), and its melting flow index is 3.1 g/10 min. The polybutadiene content is 7% in HIPS. PBT was supplied by Shanghai Terylene Chemical Co. (Shanghai, China), and its melting flow rate is 13 g/10 min. Dicumyl perox-

ide (DCP), obtained from Xizhong Chemical plant (Beijing, China), was used as an organic peroxide initiator. Its half-life is ~15 sec at 190°C. Reagent-grade GMA was purchased from Suzhou Anli Chemical Co. (Suzhou, China) and used without purification.

Preparation of HIPS-g-GMA

The graft reaction of HIPS with GMA was conducted in the molten state by using a Brabender mixer (Melchers-Ferrostaal GMBH & Co. KG, D-2800 Bremen, Germany) processed at 50 rpm for 5 min at 180°C. HIPS was introduced into the mixing chamber first, and then GMA and DCP were added simultaneously.

Purification and Characterization of HIPS-g-GMA

To remove residual GMA and possible homopolymer of GMA, the following purification procedure was adopted: The grafted HIPS samples were pressed into films with thickness about 0.2 mm. Then the films were extracted by using boiling benzene for at least 12 h.

An FTS-7 Fourier-transform infrared (FTIR) spectrophotometer (BioRad Co., USA) and an ESCA CAB MK-II (VG Co., England) electron spectrometer were used to qualitatively characterize the formation of the HIPS-g-GMA copolymer.

Evaluation of the content of GMA in the copolymers was carried out by using a hydrochloric acid/xylene titration method. A copolymer sample was added to 100 mL of xylene. After the sample was completely dissolved, 0.5 mL of concentrated hydrochloric acid (1.2N) was added to open the epoxide rings of GMA. Then, the solution was titrated with 0.05N methanolic sodium hydroxide solution to the first red color of the end point. Phenolphthalein/ethanol was used as the red indicator. The grafting degree (GD) of GMA was calculated from the following equation:

$$GD = [C_{\text{HCL}}V_{\text{HCL}} - C_{\text{KOH}}V_{\text{KOH}}] \times M_{\text{GMA}}/W_s \times 100\%$$

where V , C , M , and W_s are the volume, concentration, molecular weight, and weight of the sample, respectively.

Blend Preparation

PBT was dried for 24 h at 120°C before melt blending. The polymers were melt-mixed by using a Brabender twin-screw extruder operated at a rotation speed of 20 rpm and a temperature range

of 230°C. Compositions of PBT/HIPS (HIPS-g-GMA) had weight ratios of 75/25, 45/55, and 25/75, respectively.

Morphology Observation

Morphology of the blend was observed with a scanning electron microscope (SEM 1 JXA-840, JEUL, Japan) at an accelerating voltage of 25 kV. Blend samples were fractured at the temperature of liquid nitrogen, and the fractured surface was coated with gold; at the same time, the fractured surface of the sample was also observed, using a tension test.

Thermal Analysis

The thermal behavior of blend samples was determined on a Perkin-Elmer DSC II (USA). The blend samples were rapidly heated to 250°C and remained at this temperature about 10 min to eliminate heat history, then samples were heated and cooled at a rate of 10°C/min under a nitrogen atmosphere.

Dynamic Mechanical Thermal Analysis

Loss tangents ($\tan\delta$) for binary blends were measured using a dynamic mechanical thermal analyzer with a tension at a frequency of 3.33 Hz and a heating rate of 3°C min⁻¹. The samples were prepared using a compression-molding machine, and the dimension of the specimen was 12 × 5 × 1 mm.

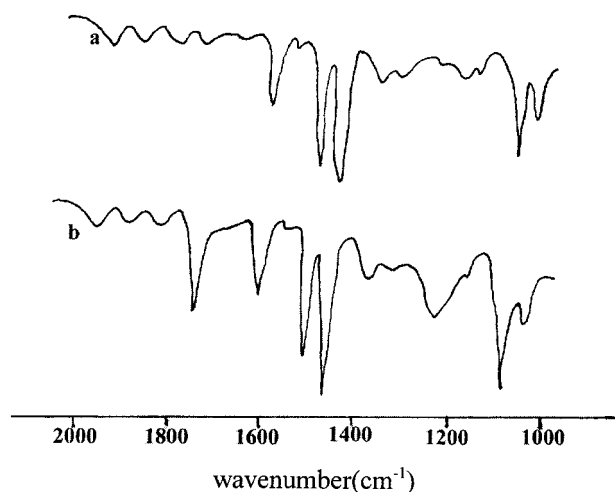


Figure 1 Fourier transform infrared spectra of (a) plain high-impact polystyrene (HIPS) and (b) HIPS-g-glycidyl methacrylate.

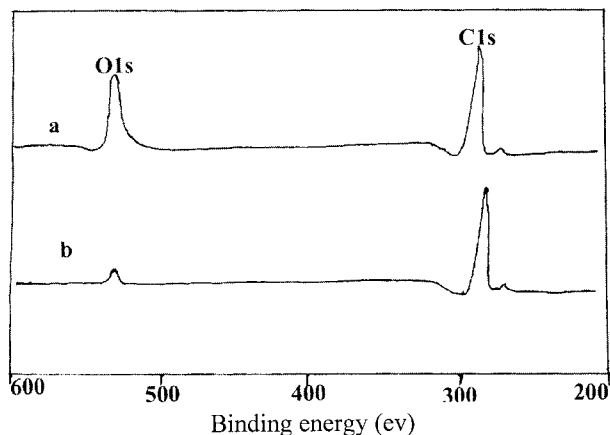


Figure 2 Electron spectroscopy for chemical analysis spectra of (a) plain high-impact polystyrene (HIPS) and (b) HIPS-g-glycidyl methacrylate.

Tension Property Measurement

Dumbbell-shaped specimens were prepared at 230°C by hot-press molding. Tension tests were carried out on an Instron 1121 machine (England) at room temperature with a crosshead speed of 5 mm min⁻¹. Five specimens of each blend were tested, and average values were taken as experimental data.

RESULTS AND DISCUSSION

Characterization of HIPS-g-GMA

FTIR spectra of the HIPS and HIPS-g-GMA are shown in Figure 1. In the spectrum of HIPS-g-GMA, the new absorption band at 1730 cm⁻¹ appeared; however, this band was not observed in the spectrum of pure HIPS. This characteristic band is attributed to contributions of carbonyl group of HIPS-g-GMA, because the unreacted GMA has been removed from the sample, and GMA has been grafted onto the HIPS molecular chains. Figure 2 showed X-ray photoelectron spectroscopy spectra of the HIPS and HIPS-g-GMA. The intensity of the oxygen peak of HIPS-g-GMA is significantly larger than that of the plain HIPS. This can be tentatively explained as follows: the small O_{1s} peak of the pure HIPS originates from the absorbed oxygen on the surface of the HIPS sample; the O_{1s} peak of the HIPS-g-GMA sample comes from two contributions: one is from the absorbed free oxygen, and the other is from the oxygen element of the carbonyl group in the grafted copolymer of HIPS and GMA.

Table I Effect of Concentrations of Dicumyl Peroxide (DCP) and Glycidyl Methacrylate (GMA) on Content of GMA in High-Impact Polystyrene (HIPS)-g-GMA

HIPS (g)	DCP (wt%)	GMA (wt%)	Content of GMA in HIPS-g-GMA (wt%)
100	0.5	10	0.84
100	1.0	10	1.54
100	1.5	10	1.95
100	2.0	10	1.51
100	1.5	2.5	0.65
100	1.5	5.0	1.23
100	1.5	7.5	1.59
100	1.5	10.0	1.95
100	1.5	12.5	0.86

The GMA content in the HIPS-g-GMA copolymers depended on concentration of the initiator and monomer in the melt grafting reaction, as shown in Table I.

Thermal Properties

Differential scanning calorimetry (DSC) thermograms of PBT/HIPS and PBT/HIPS-g-GMA blends are shown in Figures 3 and 4, respectively. The melting and crystallization parameters were summarized in Table II. As shown in Figure 3, neat PBT exhibits two melting peaks, and the peak at higher temperatures is dominant compared with that at lower temperatures. Such multiple endotherms have been reported for a number of semicrystalline polymers, and the origin of these peaks has been ascribed to the presence of different morphologies and simultaneous melting and reorganization of the crystallites.¹⁸⁻²² The exothermal peaks resulting from the reorganization have been observed on the DSC traces between two endothermal peaks. The melting temperatures listed in Table II are responsible for the peaks at higher temperatures on DSC scanning traces. In the HIPS/PBT blends, the melting temperatures depend on the composition of the blends; however, the melting temperature decreases with an increase in the content of HIPS-g-GMA in the HIPS-g-GMA/PBT blends. The perfection of the crystals was hindered, and the relative crystallinity obviously decreases in the reaction blends. The reaction between HIPS-g-GMA and PBT should hinder the movement and fold in the order of PBT molecular chains, then lead to the reduction of crystallization.

The effect of HIPS and HIPS-g-GMA on the crystallization behavior of PBT from melt in these blends was shown in Table II and Figure 4, respectively. The fractionated crystallization of PBT can be concluded from Figure 4 when PBT consists of dispersed phases, especially with 75 wt% of HIPS-g-GMA and/or HIPS in the blends. It correlates with the enhanced compatibility and diminished domain size of the dispersed phase particles in the blends.^{23,24} The crystallization behavior of PBT in the blends can be interpreted as a further evidence of the interaction between two polymers. The fraction crystallization phenomenon is more significant in the reactive compatible blend than that in HIPS/PBT blend. It could be concluded that the domain size decreases remarkably in the reactive blend, and the miscibility between PBT and HIPS-g-GMA

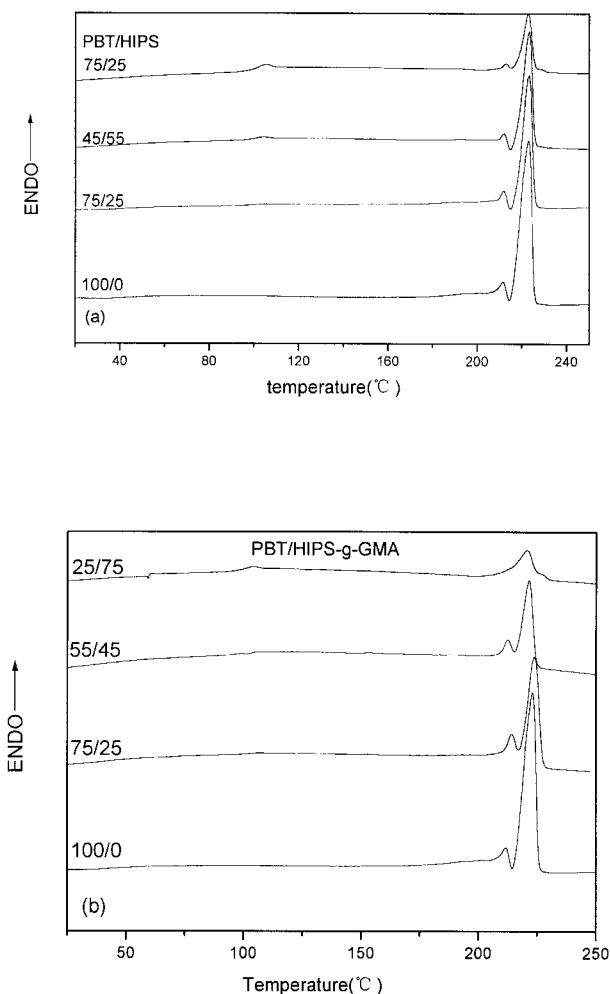


Figure 3 Differential scanning calorimetry thermograms of the heating of the binary blend: (a) poly(butylene terephthalate)/high-impact polystyrene (PBT/HIPS), (b) PBT/HIPS-g-glycidyl methacrylate.

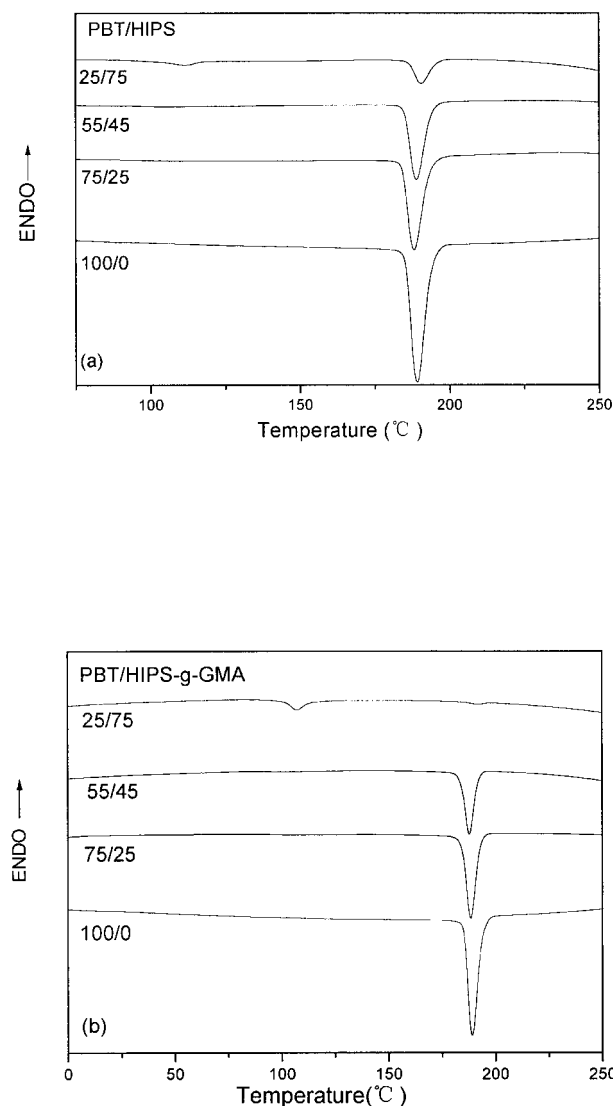


Figure 4 Differential scanning calorimetry thermograms of the cooling of the binary blend: (a) poly(buthylene terephthalate)/high-impact polystyrene (PBT/HIPS), (b) PBT/HIPS-g-glycidyl methacrylate.

was improved compared with the PBT/HIPS blend.

However, the peak temperature corresponding to the crystallization of the sample from melt, T_c , increases slightly compared with the neat PBT when HIPS and/or HIPS-g-GMA is the continue phase in the blend. It means that the crystallization of PBT could be carried out at higher temperature. The weak effect of the crystallization nuclei of HIPS and HIPS-g-GMA on the crystallization of PBT could be considered when the PBT is the dispersed phase in the blends. The crystallization process is very complex in the immiscible polymer blends. The intermolecular interaction between two components can lead to the depression of the crystallization rate, reduction of T_c , and increment of undercooling degree. The non-crystallizable component, HIPS and HIPS-g-GMA, with high viscosity may hinder the transfer and movement of the crystallizable molecular chains of PBT. However, the nucleating effect of HIPS and HIPS-g-GMA in the blends is predominant among these competitive factors.

Morphology

The morphology of the fractured surface of the sample in liquid nitrogen and the fractured surface of the tensile sample is shown in Figures 5 and 6, respectively. The significant differences were observed between PBT/HIPS physical blend and PBT/HIPS-g-GMA reactive blend. The blends of PBT/HIPS showed a sharp interface and poorer adhesion between dispersed phase and matrix. However, in the reactive blend of PBT/HIPS-g-GMA, as expected, the minor phase was hardly distinguishable as the result of the improvement in dispersibility. This morphological difference was attributed to the reaction between the ester

Table II Thermal Properties of High-Impact Polystyrene (HIPS)/Poly(Buthylene Terephthalate) (PBT) and HIPS-g-Glycidyl Methacrylate (GMA)/PBT Blends

Sample	T_m (°C)	ΔH_m (J/g)	Relative crystallinity ^a	T_c (°C)
HIPS/PBT				
0/100	223.9	54.30	100.00	188.1
25/75	223.2	52.97	97.6	188.1
45/55	223.3	53.65	98.8	188.9
75/25	223.0	53.24	98.0	190.6
HIPS-g-GMA/PBT				
25/75	223.9	48.93	90.1	188.4
75/25	220.7	50.12	92.3	192.0

^a Relative crystallinity = ΔH_m of blend / [(wt % of PBT in blend) (ΔH_m of neat PBT)].

groups of GMA in HIPS-g-GMA and PBT. This behavior was also observed in morphology of the fractured surface of the tensile sample. The morphological feature of the fractured surfaces of the tensile samples of the incompatible blend was similar to that of the sample fractured in liquid nitrogen, and they exhibited clear boundaries and smooth interfaces between the dispersed phase and the matrix. However, the average domain size obviously got smaller, so as to be hardly distinguished, and no sharp interfacial boundaries were seen in the compatible blend, as shown in Figure 6. This result confirmed further that the reaction of ester groups of GMA in HIPS-g-GMA and PBT enhanced interfacial adhesion in the reactive blends.

Dynamic Mechanical Analysis

In miscible blends, the dynamic mechanical properties depend on the properties of component

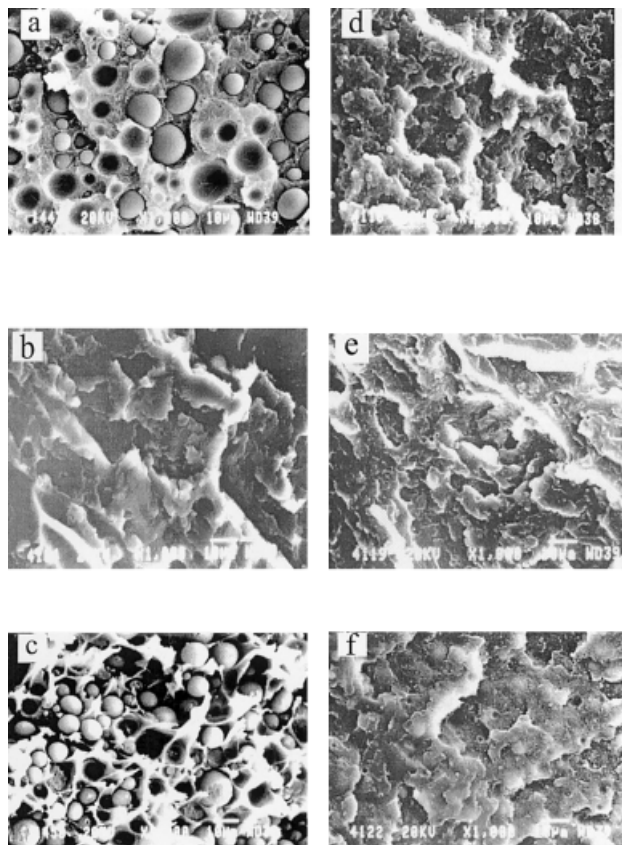


Figure 5 Scanning electron microscope micrographs of the poly(butylene terephthalate)/high-impact polystyrene (PBT/HIPS) blends with compositions of (a) 75/25 wt/wt, (b) 55/45 wt/wt, (c) 25/75 wt/wt, and PBT/HIPS-g-glycidyl methacrylate blends with compositions of (d) 75/25 wt/wt, (e) 55/45 wt/wt, (f) 25/75 wt/wt.

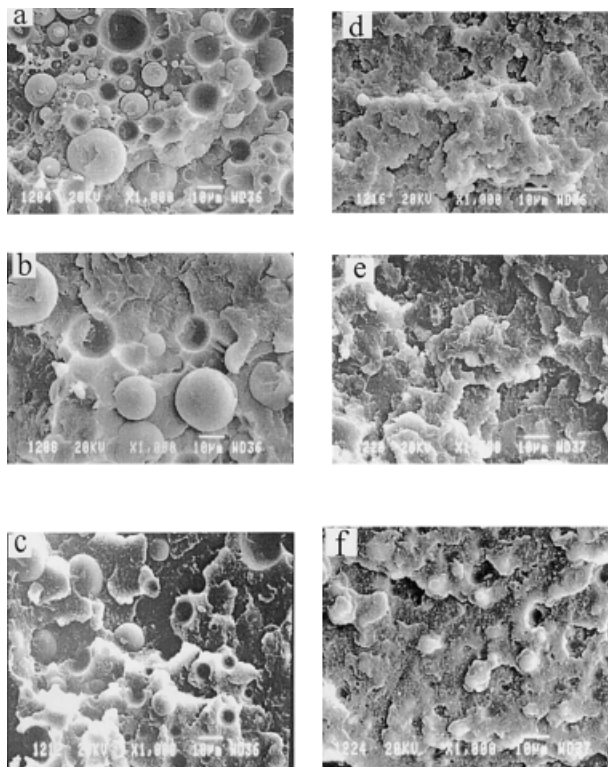


Figure 6 Scanning electron microscope micrographs of the fractured surface of the tensile sample of poly(butylene terephthalate)/high-impact polystyrene (PBT/HIPS) blends of (a) 75/25 wt/wt, (b) 55/45 wt/wt, (c) 25/75 wt/wt, and PBT/HIPS-g-glycidyl methacrylate blends with compositions of (d) 75/25 wt/wt, (e) 55/45 wt/wt, (f) 25/75 wt/wt.

polymers, polymer/polymer interaction, and miscibility, whereas phase morphology, domain size, distribution, and the adhesion of the interface are critical parameters in immiscible blends. The phase structure of a blend is referred to by the number of glass transition temperatures observed in the dynamic mechanical spectra. That is, the appearances of two glass transitions are clear evidence of phase separation, and that of a single glass transition at a temperature intermediate between those of the pure components indicates miscibility. Figure 7 shows the temperature dependence of the loss factor ($\tan\delta$) for the HIPS/PBT and HIPS-g-GMA/PBT blends with different composition. Clearly, two glass transition temperatures, T_{g1} and T_{g2} , were observed. The mechanism of the relaxation from the molecular motion has been investigated by a number of workers. The sharp dynamic mechanical damping peak at about 110°C is a result of the glass transition of PS in HIPS and HIPS-g-GMA, and the broad peak near 64°C is associated with the glass tran-

sition temperature relaxation of the PBT component in the blends.

The presence of two peaks in the blends confirms the immiscibility between the phases.

The dynamic mechanical spectrum has become a classical method for the determination of miscibility because the height and position of the mechanical damping peaks are affected remarkably by miscibility, intermolecular interaction, interface feature, and morphology. The dynamic mechanical properties of the blends are also affected by the composition, with particular emphasis on the amount of the minor composition. In the blends of HIPS and/or HIPS-g-GMA containing small amount of PBT, T_{g2} peaks are not clearly visible because PBT is a semicrystallizable polymer and the damping peak resulted from the glass transition associated with the molecular

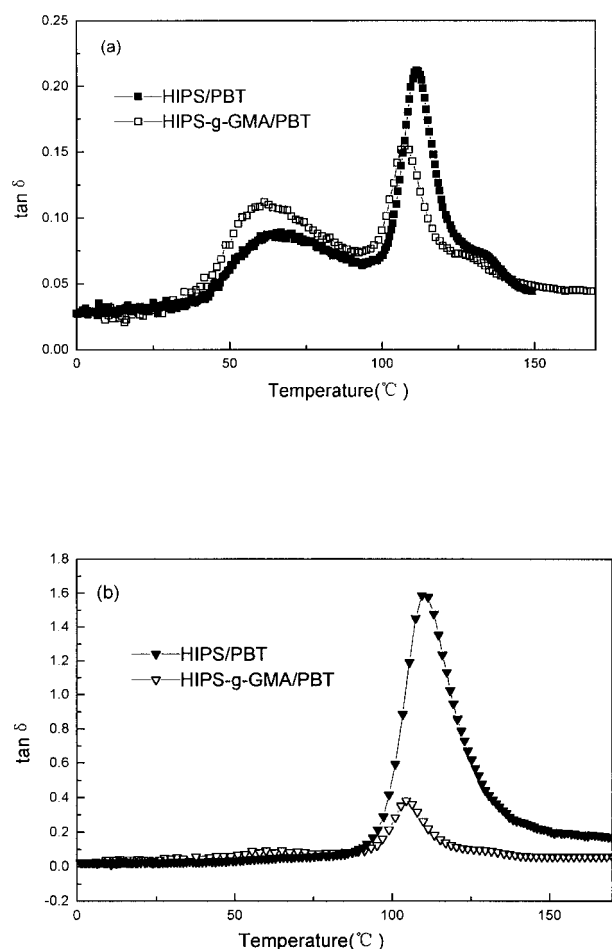


Figure 7 Dynamic mechanical analyzer spectra of $\tan \delta$ versus temperature of the poly(buthylene terephthalate)/high-impact polystyrene (PBT/HIPS) (HIPS-g-glycidyl methacrylate) blend: (a) 75/25 wt/wt, (b) 25/75 wt/wt.

Table III Glass Transition Temperatures of Poly(Buthylene Terephthalate) (PBT), High-Impact Polystyrene (HIPS), and Their Blends

Sample	T_{g1} (°C)	T_{g2} (°C)
HIPS	—	113.1
PBT	—	109.5
HIPS-g-Glycidyl Methacrylate (GMA)	64.9	—
PBT/HIPS 75/25	65.0	110.8
PBT/HIPS 55/45	64.9	107.5
PBT/HIPS 25/75	—	109.5
PBT/HIPS-g-GMA 75/25	61.5	107.5
PBT/HIPS-g-GMA 55/45	61.7	105.9
PBT/HIPS-g-GMA 25/75	60.0	104.5

motion of the amorphous phase is intrinsically weak. The glass transition temperatures of the blends and neat polymers are summarized in Table III.

The glass transition temperature of the PS phase in the HIPS-g-GMA copolymer decreases slightly compared with that of neat HIPS. The grafting GMA chain on HIPS acts as a plasticizer in the HIPS-g-GMA copolymer. In HIPS/PBT blends, both T_{g1} and T_{g2} shift inward slightly. Poor miscibility between HIPS and PBT was measured. However, they were not entirely immiscible. The further shifting of the glass transition temperature of PS phase to lower temperatures is observed in PBT/HIPS-g-GMA samples, and the T_{g2} decreases as the amount of HIPS-g-GMA in these blends is increased—this is evidence that the GMA group in a HIPS-g-GMA copolymer enhances the miscibility between PBT and PS phases. The reaction between PBT and HIPS-g-GMA is postulated. According to the miscibility criterion, the glass transition temperature of PBT should have shifted to a higher temperature. On the contrary, the glass transition temperature of the PBT phase decreases with an increase in the amount of HIPS-g-GMA in the PBT/HIPS-g-GMA blends. The factors that affected the glass transition temperature of PBT phase in the blends are complex. In addition to the miscibility, the state of order determines the physical and technological properties of polymer solids. These also determined to a great extent the molecular motions of the different groups in the long chains. The influence of crystallization, orientation, and absorbed low-molecular weight compounds on the relaxation processes of PBT and PET has been discussed by several authors.²⁵ Usually, the decrement of the glass transition temperature, T_{g2} , is

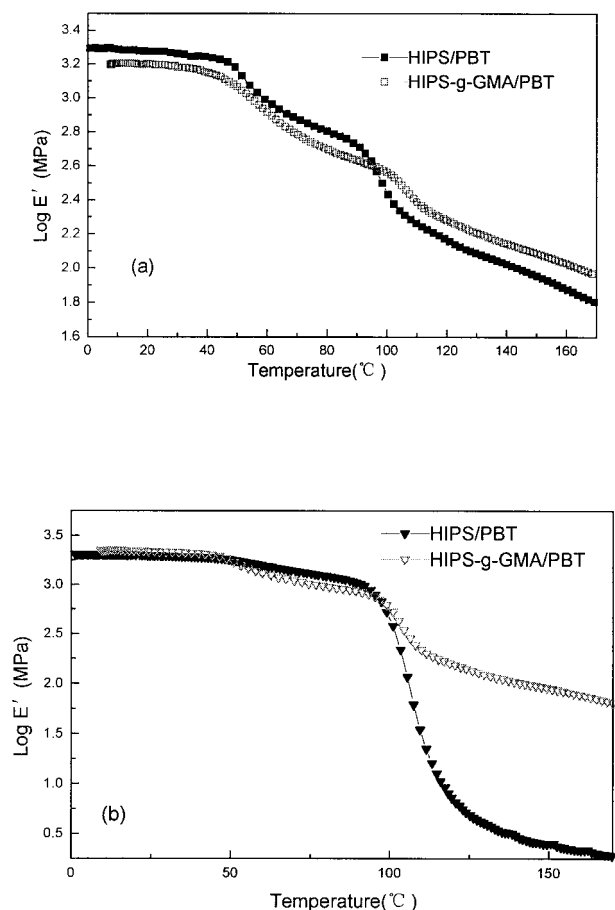


Figure 8 Dynamic mechanical analyzer spectra of storage modulus versus temperature of the poly(butylene terephthalate)/high-impact polystyrene (PBT/HIPS) (HIPS-g-glycidyl methacrylate) blend: (a) 75/25 wt/wt, (b) 25/75 wt/wt.

attributed to the decreasing of the crystallinity of PBT phase associated with the reaction between PBT and GMA in the HIPS-g-GMA copolymer, which forced PBT chains and restrained the molecular chains fold-in order. These results are dealt with the depression of the melting temperature, T_m , of PBT in the reactive compatible blends. The interaction between the epoxy group in HIPS-g-GMA and the carboxyl and/or hydroxyl groups in PBT destroyed the hydrogen bonds in the PBT phase; therefore, the glass transition temperature of PBT shifts to a lower temperature.

In addition to the above mentioned differences, there are a few differences worthy of note on the storage modulus, E' , versus temperature plots between HIPS/PBT and HIPS-g-GMA/PBT blends, as shown in Figure 8. The storage modulus, E' , is higher for HIPS/PBT blends compared

with that of HIPS-g-GMA/PBT ones with the same composition at the temperature range of from about 50° to 95°C, that is, from T_{g1} to T_{g2} , because of the lower crystallinity degree of the PBT phase in the reactive compatible blends. In contrast to the temperature region between the glass transition temperatures of the component polymers, HIPS-g-GMA/PBT blends exhibited a higher storage modulus than HIPS/PBT blends at temperatures over 95°C, especially when PS is the continue phases in the blends. E' exhibits rubber-like plateau behaviors in the temperature range from 95° to 160°C. Over the glass transition temperature, the plateau modulus of multiphase polymer material usually was determined by the physical cross links, chemical cross links, physical entanglement, and the interaction between the components in the blends.

In the crystallizable polymer blends, there are lots of small crystallites that act as physical cross links, and hence, the viscoelastic properties of the blends are related strongly to the content of crystallites. As mentioned above, PBT phase exhibits a higher degree of crystallinity in HIPS/PBT blends than that in the HIPS-g-GMA/PBT blends; however, they show lower plateau modulus. These results indicate that a higher entanglement density and strong interaction between components were created in the reactive, compatible HIPS-g-GMA/PBT blends. The chemical interaction between HIPS-g-GMA and PBT strongly affects the dynamic mechanical properties of the blends.

Tensile Properties

The phase morphology and the interfacial adhesion between component polymers influence the tensile properties of polymer blends. Two-phase morphology with lack of adhesion between the component polymers leads to premature failure and, thus, to lower tensile strength. The tensile properties of binary-compatible and physical blends were summarized in Table IV. In this case, as expected, the tensile strength at breakage and tensile elongation at breakage of compatible blends were higher compared with physical blends under the same composition. From the foregoing discussion, it could be seen that the interaction of an epoxy group and an carboxyl or hydroxyl group in a compatible blend enhanced interfacial adhesion of the binary blend and resulted in the uniform distribution of a minor phase. The fine phase morphology and strong interfacial adhesion could transfer effectively applied

Table IV Tensile Properties of Poly(Buthylene Terephthalate) (PBT) Blends with High-Impact Polystyrene (HIPS), and HIPS-g-Glycidyl Methacrylate (GMA)

Sample	Tensile Strength (MPa)	Elongation at Break (%)	Tensile Modulus (Mpa)
HIPS/PBT			
25/75	41	4.8	1002
50/50	32	3.7	881
75/25	20	2.5	850
HIPS-g-GMA/PBT			
25/75	46	5.4	885
75/25	24	2.8	862

force between component phases by interface. Hence, the mechanical properties of the reactive blend were better than that of the physical blend.

CONCLUSIONS

The morphology and the thermal, dynamic mechanical, and tensile properties of PBT blends with HIPS and HIPS-g-GMA have been studied. HIPS and HIPS-g-GMA could affect crystallization of PBT, but the effect of HIPS-g-GMA on the crystallization behavior of PBT was more obvious because of the interaction between the epoxy group and the carboxyl or hydroxyl group in the compatible blend. As a nucleating agent, HIPS-g-GMA made PBT crystallize from melt at a higher temperature. As a function-grafting copolymer, HIPS-g-GMA depresses the crystallinity degree and lowers the perfection of the crystals of PBT with lower melting points. The morphological feature shows that the smaller domain size and uniform dispersibility, as well as blurry interface, were seen in the compatible blend. The HIPS-g-GMA grafting copolymer was an effective compound in creating fine morphology and enhancing the interfacial adhesion to the binary blend. These results dealt with the tensile strength, dynamic mechanical, and thermal properties.

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