Toughening of Poly(ethylene terephtalate) (PET) Bottle Wastes by Modified Styrene-Butadiene Rubber (SBR) Elastomer

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Summary: Modified SBR was blended with dried PET bottle wastes in an internal mixer. During the process mechanical and morphological properties were studied. When PET bottle wastes were blended with unmodified SBR, the final blend had a rough morphology and low impact strength. In contrary, blending of PET with modified SBR lead to smooth and fine morphology. Utilizing grafted SBR in PET blends creates an enormous difference in particle size and morphology, which is a result of powerful interactions and effective chemical bonding between the components of the blend. The final product had high impact strength in comparison with PET and unmodified SBR blend.These results are mainly related to formation in situ of PET/SBR graft copolymer in interface, which is produced by chemical reaction among active maleic anhydride groups and active PET groups.

Keywords: compatibilization; impact-properties; interfacial-adhesion; morphology; toughening

Introduction

Poly(ethylene terephtalate) (PET) is widely used as an engineering thermoplastic.[1] One draw back for this polymer is its sensitivity to notch formation which causes brittle failure at room temperature. One of the methods to overcome this problem is blending of this plastic by an elastomer.[2–6] In this work modified rubber was blended with PET. Then morphological and impact properties of these blends were studied.

Experimental Part

Materials

PET bottle wastes taken from general use (Melting point determined by DSC is 248.2°C) its source granule was derived TexPET, Korea. Styrene-Butadiene Rubber (SBR) (random copolymer) from Bandar – Imam Petrochemical Co. (poliran 1502) has a density of 0.93 gr/cm^3 (ASTMD 790), (styrene content 22.5–24.5% weight). Styrene-Butadiene Rubber grafted with maleic anhydride (SBR-g-MAH) was prepared through our previous study.[7] Irganox from Ciba-Geigy was applied in order to prevent oxidation (Melting of 170°C).

Equipment

An internal mixer (Rheomixer HBI SYS 90 With chamber capacity of 300 ml and fill factor of 75% was used in the mixing process and a injection molding machine (Imen Machine Co) was used to prepare samples for tests. Impact tests (Izod notched) were carried out on Zwick device under ASTM D-256. Scanning electron microscopy (SEM) from Japanese company of Jeol (JXA-840) was used to study morphology of samples.

Blending Procedure

PET bottle wastes are collected, grinded, washed and then dried for 12 hours at 110 °C, then according to the designed

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Table 1.
Formulations used in blending.

Code	Formulation	PET (phr)	SBR-g-MAH (phr)	Irganox (phr)
K1	PETW50	100	0	0.1
K2	PETWSBRP	100	15	0.1
K3	PETWSBRd2	100	15(1.5 phr MAH)	0.1
K4	PETWSBRd3	100	15(2 phr MAH)	0.1
K5	PETWSBRd4	100	15 (2.5 phr MAH)	0.1

formulations shown at Table 1, blends were prepared using an internal mixer with a speed of 50 rpm at 260 °C. components addition sequence is as follows: firstly PET with Irganox is added and then at fourth minute SBR-g-MAH is added to the system. At seventh minute mixing is stopped.

Results and Discussion

Morphology Studies

Figure 1 shows micrographs for formulations (k2–k5). In this work, SBR droplets appear as large holes, which is common in uncompatibilized polymer blends. Therefore SBR has been maleated (modified with maleic anhydride as compatibilizer) to achieve more powerful interface, which leads to higher impact resistance. In k3 formulation although, the droplets are stretched and some are big, but the effect of compatilization of PET and SBR was more obvious than the formulation K2. Subsequently, in K4 formulation a good dispersion of SBR droplets was obtained. The results in K5 formulation were the same as former one but the droplets were

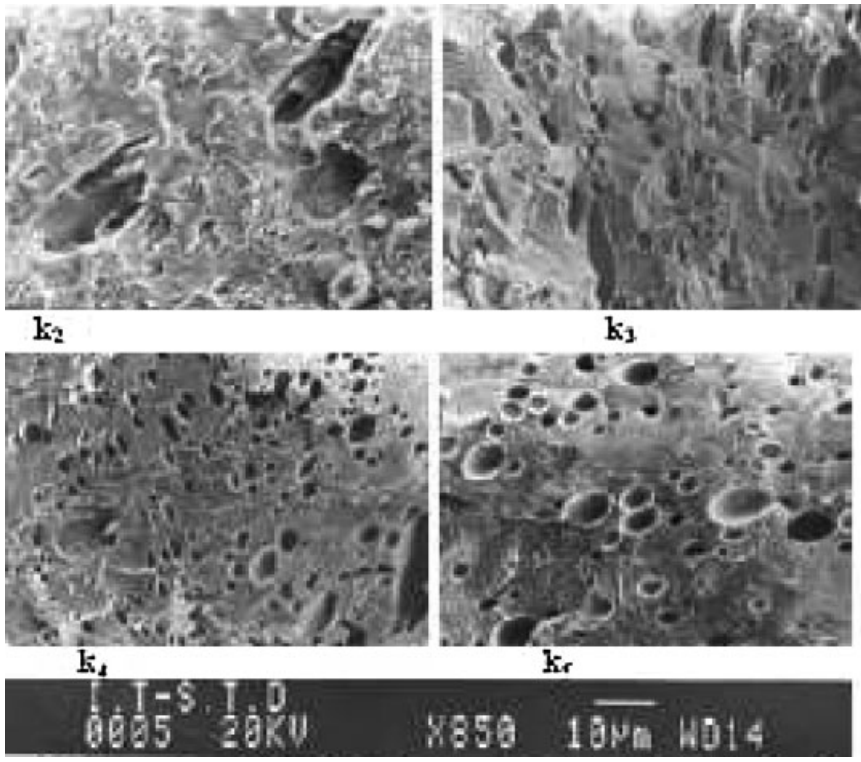

Figure 1.
SEM illustration for K2, K3, K4, K5 formulation.

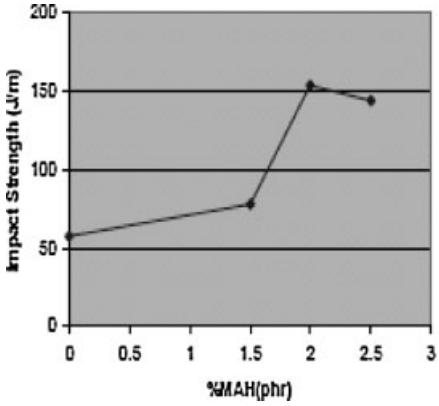

Figure 2.
Impact strength of the PET,SBRg as a function of MAH concentration.

a bit larger. The results show the role of compatibilizer in increasing interfacial adhesion.

Impact Properties

Figure 2 shows results of impact tests carried out on modified and unmodified blends (formulations K2-K5). As the compatibility of blends increases; Impact strength is increased from 57 J/m to 153 J/m at the maleic anhydride concentration of 2 phr. When unmodified SBR is blended with PET, the dispersed SBR could not act as effective stress dispersant due to large particle size and the lack of adhesion between the phases. However, when SBR-g-MAH was blended with PET, the dispersed SBR phase became small enough to act as a stress dispersant. Moreover, the adhesion between the phases would transfer the stress field from PET matrix to the dispersed elastomer effectively. All this is due to chemical bonding between PET and modified SBR.

Conclusions

Modified SBR was blended with PET bottle wastes and compared with simple blend of PET/SBR. In view of blend morphology, dispersed particle sizes of PET/SBR-g-MAH were finer than those of the PET/SBR blends, and the PET/SBR-g-MAH blends showed homogeneous dispersions and better adhesions between the dispersed and matrix phases. This indicates that PET-g-SBR graft copolymers were generated during the melt processing and acted as a compatibilizer. In mechanical properties, the PET/SBR-g-MAH blends showed improved notched – Izod impact strengths over the PET/SBR blends.

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