SEBS가 LDPE/PS 블렌드계의 용융신장과 회복거동에 미치는 영향

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The Effect of SEBS on the Melt Elongation and Recovery Behavior of LDPE/PS Blends

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Introduction

The relationships between the interfacial tension and rheological properties of LDPE/PS blends have been investigated. Rheological properties of the polymer blend are closely related to the interfacial tension between two polymers. Breaking thread method was used to measure the interfacial tension between PS and LDPE, or that between PS and LDPE containing various amount of compatibilizer.[1,2] SEBS was used as a compatibilizer, and the effects of compatibilizer on the rheological properties of blends have been investigated. As for the rheological properties, melt elongation and retraction behaviors were observed.

Materials

LDPE(Tm 107.43℃, MI 3.0g/10min, density 0.92g/㎤), PS(Tg 97.0℃, MI 5.8g/10min, density 1.05 g/㎤), and SEBS(density 0.9g/㎤, MI 65g/10min, EB block 70%, styrene block 30%) were used in this study. Blend compositions of LDPE/PS were 10/90, 20/80, 30/70, and the effects of SEBS copolymer were studied in the 20/80 LDPE/PS blend. The copolymer compositions investigated were 0.5, 1, 3, 5, 7wt% relative to the total weight of the blends. Blending was carried out in a twin-screw extruder (Haake Rheomix 252) with 60rpm at 210℃.

Experimental

Breaking thread method was used in measuring the interfaicial tensions. Films of LDPE were pressed using a press at 210℃. The 50~100m diameter PS fibers were obtained by drawing melted pellets on a hot plate. PS thread was embedded in two LDPE films. The observation was done on a Nikon optical microscope in transmission mode. Images were taken pictures and the amplitudes and the wavelengths of the thread were analyzed with time at 180℃. Interfacial tension was calculated by measuring the evolution of the thread distortion amplitude versus time. Detailed procedures can be found in the references.[3,4]

ARES was used to measure the dynamic modulus. Experiments were carrried out with 25mm plate diameter, 1.5mm gap distance, 10% strain rate, and 0.1~100 rad/sec freqeuncy range.

Melt elongation and recovery measurements were performed in a rotary clamp elongational rheometer. For elongation viscosity, test temperature was 180℃ and elongational rates were 0.05, 0.1, and 0.25. Test samples were made by capillary rheometer. During elongation, the strain rate is kept constant. The strain (Hencky strain) increases linearly with time and is related to the stretch (or stretch ratio) by

$$\varepsilon(t) = \dot{\varepsilon}_o t = \ln \lambda(t)$$

Recovered stretch ratios were measured by cutting the elongated sample. After cutting, samples immediately shrank into small pieces due to the elastic portion of elongation. The ratio is defined as follow.

$$\lambda_r(t') = L_A / L(t')$$

where L_A is the cutting length and $L(t')$ is the length of the same cut-off after recovery time t'.

The transient recovery was measured by marking photos of the cut-offs at different instants during the recovery period. For this purpose, a digital-camera had been installed on top of rheometer housing. Samples were cut after being stretched for 20 seconds with stretch ratio of 0.1. The initial cut-off length was 10cm.

Results and Discussions

Interfacial tension changes of LDPE/PS blends with SEBSs are shown in Fig. 1. Interfacial tension of LDPE/PS is 8.26 dyne/cm which is somewhat large compared to those in previous results.[1,3,4] This is due to the large viscosity ratio of LDPE/PS in this system. The interfacial tension decreases rapidly with SEBS contents to 1wt% and then level off to a saturation value of 3.5 dyne/cm. SEBS decreases the interfacial tension of LDPE/PS blend system and as a result, is expected to reduce the size of the dispersed phase.

Various experiments about the transient elongational viscosities of LDPE/PS blends have been performed for different elongational rates(0.05, 0.1, and 0.25, respectively). As LDPE contents are increased, strain hardening is enhanced noticeably. PS shows less sensitive strain hardening behavior to the elongational rates than LDPE. Detailed data will be represented in the presentation. Figure 2 shows the effect of SEBS on the elongation properties for LDPE/PS=20/80 blends. When the contents of SEBS are 0.5 and 1wt%, it acts as a compatibilizer and reduces the interfacial tension, hence reduce the strain hardening. More addition of SEBS saturate the interface and as a result, increase the elasticity.[5]

Figure 3 represnets the storage modulus results for LDPE/PS composition 20/80. When the SEBS contents are 0.5 and 1wt%, there are slight drops of storage modulus, while more SEBS than 3wt% increase the storage modulus. This is similar results with that of Fig. 2.

Melt recovered stretch ratio of LDPE/PS= 20/80 blends with various SEBS contents are represented in Fig. 4. Recovery ratio of LDPE/PS=20/80 reaches to 3. As LDPE contents increase, the recovery ratios increase. When LDPE/PS=30/70, its value reaches to 7.14 due to the increase of the interfacial energy.[6] When SEBS is added to 1wt%, the ratio is reduced to 2.58. As SEBS content comes to 5wt%, recovered stretch ratio increased to 3.93 again. Initially, SEBS reduces the interfacial energy. After saturation of around 3wt%, however, it increases the elasticity.

Conclusions

The relationships between the interfacial tension and rheological properties have been investigated for LDPE/PS blends in this study. SEBS was examined as a compatibilizer. The measured interfacial tension of LDPE/PS blend by breaking thread method was 8.26 dyne/cm, and it decreased rapidly with SEBS contents to 1wt% and then level off to a saturation value of 3.5 dyne/cm. In melt elongation measurements, no more than 1wt% SEBS acted as a compatibilizer and reduced the interfacial energy, hence reduced the strain hardening. More than 3wt% SEBS, however, saturated the interface and increased the strain hardening behavior. Similar results were obtained in melt recovery experiments. More than 3wt% SEBS increased the recoverd stretch ratio compared to LDPE/PS blend.

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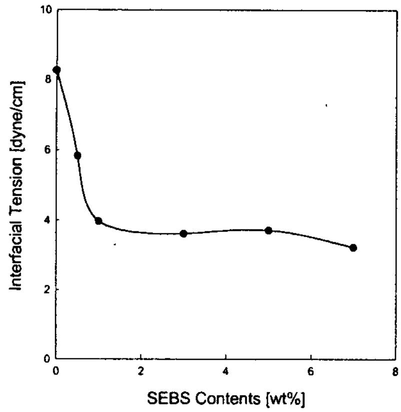

Fig. 1. Interfacial tension changes with SEBS contents in LDPE/PS matrix.

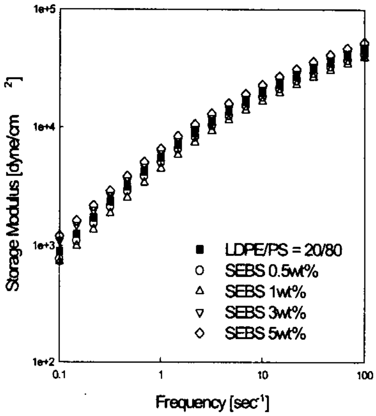

Fig. 3. Storage Modulus vs. frequency with vsrious SEBS contents for LDPE/PS=20/80.

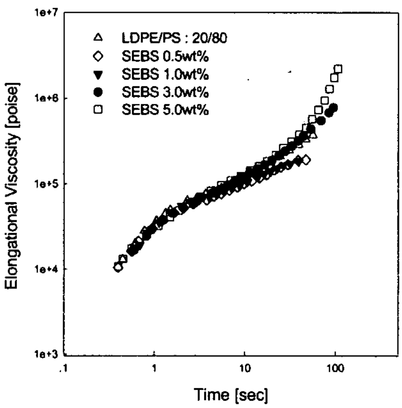

Fig. 2. Elongational viscosities of various SEBS contents for LDPE/PS=20/80.

Elongation rate is 0.05.

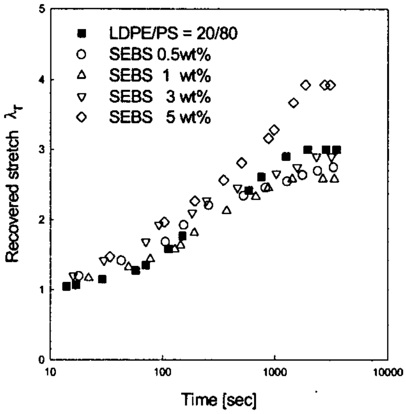

Fig. 4. Recovered stretch ratios of various SEBS contents for LDPE/PS=20/80.