PP/SAN/PP-g-SAN 블렌드의 유변학적 성질과 계면 장력에 관한 연구

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Rheological Properties and Interfacial Tension of Poly(propylene)-Poly(styrene-co-acrylonitrile) blend Containing Graft Copolymer

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Introduction

There are a few methods for the determination of the interfacial tension for the polymer blend. Among the methods, the relaxation spectrum method and morphology could be used for the determination of the interfacial tension between the components of blend (Gramespacher and Meissner , 1992; Moan et al.,2000; Riemann et al., 1997).

Polypropylene (PP) and poly(styrene-co-acrylonitrile) (SAN) are widely used in automobile industry. Therefore, blend from them should be an ideal choice to create polymer recycling and useful polymeric products possessing certain specific properties from waste PP and SAN. In the present work, the influence of the graft copolymer polypropylene-g-poly(styrene-co-acrylonitrile) (PP-g-SAN) as a compatibilizer on the morphology and rheological properties was demonstrated. In addition, the interfacial tension of PP-SAN blend compatibilized with PP-g-SAN was estimated from the weighted relaxation spectrum and morphology.

Experimental

Blend preparations

Blend of PP and SAN were prepared in 20/80 weight concentration using a 42 mm diameter twin screw extruder, with a 7:1 length to diameter screw. Concentration of PP-g-SAN copolymer, ranging from 0 to 20 wt% (phr) with respect to the whole weight fraction of PP-SAN (20/80) blend were used.

Morphology

The morphology of the cross-section of the extrudate prepared by cryogenic fracturing was examined by JEOL scanning electron microscopy (Model JSM 5200) at 20 kV accelerating voltage after gold sputter coating (500Å).

Rheology

Dynamic measurements were carried out on Advanced Rheometric Expansion System (ARES) in oscillatory shear at 6 % strain in the parallel-plate arrangement with 25 mm plate under dry nitrogen atmosphere. The sample used in this study was fabricated in a disk with 2 mm in thickness. The frequency sweeps from 0.03 to 100 rad/sec were carried out at 190, and 210 °C.

Results and discussion

Morphology

Fig. 1 (a) and (b) shows the micrographs of the cryogenically fractured cross-section surfaces for the PP-SAN (20/80) blend compatibilized with the 0, 1.0 phr, respectively. From Fig. 1 the PP-SAN blend shows droplet dispersion type morphology. In Fig. 1 when the PP-g-SAN copolymer is added to the PP-SAN (20/80) blend with 1.0 phr, the droplet size of the PP is decreased from 1.01 μm to 0.44 μm. When the PP-g-SAN copolymer concentration is higher than 1.0 phr, it is observed that the droplet size of the PP is increased.

Interfacial Tension of PP and SAN

Fig. 2 shows the weighted relaxation spectrum of the PP-SAN (20/80) blend compatibilized with 0, 0.3, 0.5, 1.0, and 3.0 phr PP-g-SAN copolymer. For the uncompatibilized PP-SAN (20/80) blend in Fig. 3, two relaxation spectrum peaks are observed at about 0.7 and 14.2 sec, respectively. The first peak (0.7sec) is related to the phases of the blend components (PP and SAN) and the second peak (14.2sec) corresponding to the long relaxation time is associated with the contribution of the interface of the PP and SAN blend. In Fig. 2, when the PP-g-SAN copolymer is added to the PP-SAN (20/80) blend up to 1.0 phr, the second relaxation time is increased from 14.2 sec to 37.4 sec. When the PP -SAN(20/80) blend compatiblized with 3.0 phr PP-g-SAN copolymer, the second relaxation time is decreased 29.7 sec. Fig. 3. shows the weighted relaxation spectrum of the PP-SAN

(20/80) blend compatibilized with 5.0, 10, and 20 phr PP-SAN (20/80) copolymer. When the PP-g-SAN copolymer is added 5.0 phr and 10 phr, it is observed the second relaxation time is decreased to 14.9 sec. For the PP-SAN (20/80) blend compatibilized with 20 phr PP-g-SAN copolymer, the second relaxation time is not able to detect.

To get the interfacial tension of the PP-SAN (20/80) blend, we used Choi and Schowalter model (Choi and Schowalter, 1975) shown in Eq. 1. The form relaxation time (τ_1) corresponding to the second relaxation time shown in Figs. 2 and 3 is expressed in Eq. 1:

$$\tau_1 = \frac{R_v \eta_m}{\alpha} \frac{(19K+16)(2K+3)}{40(K+1)} \left[1 + \phi \frac{5(19K+16)}{4(K+1)(2K+3)} \right] \tag{1}$$

where τ_1 is the form relaxation time due to the relaxation of the interface, η_m is the viscosity of the matrix, α is the interfacial tension of the blend, ϕ is the volume fraction of the dispersed phase, and $K=\eta_i/\eta_m$ is the zero shear viscosity ratio of the droplet and matrix. Applying Eq. 1 to the PP-SAN (20/80) blend, the interfacial tension of the PP-SAN (20/80) blend can be obtained. When the PP-g-SAN copolymer is added to the PP-SAN (20/80) blend with 1.0 phr, the interfacial tension is decreased from 3.50 mN/m to 0.56 mN/m. And when the PP-g-SAN copolymer concentration is higher than 1.0 phr, it is observed that the interfacial tension is increased.

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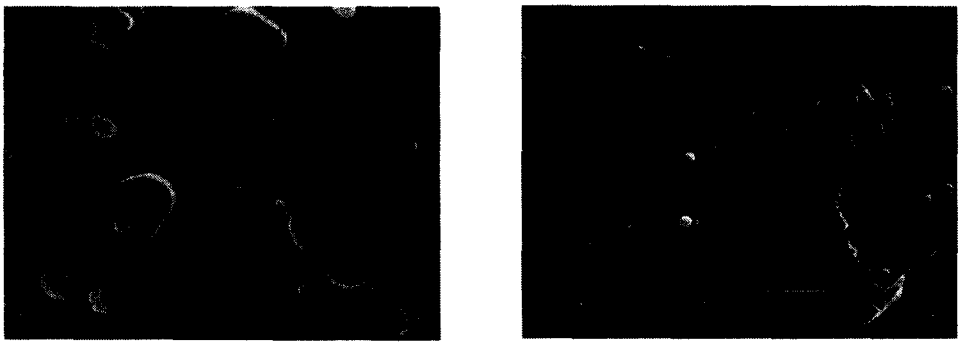
References

Choi, S. J. and Schowalter, W.R., 1975, Rheological properties of nondilute suspensions of deformable particles, Phys. Fluids, **18**, 420-427.

Gramespacher, H. and Meissner, J., 1992, Interfacial tension between polymer melts measured by shear oscillations of their blends, J.Rheol., **36**, 1127-1141.

Moan, M., Huitric, J., Mederic, P., Jarrin , J., 2000, Rheological properties and reactive compatibilization of immiscible polymer blends, J. Rheol., **44**, 1227-1245.

Riemann, R.E., Cantow, H.J., Friedrich, Chr., 1997, Interpretation of a New Interface – Governed Process in Compatibilized Polymer Blends., Macromolecules, **30**, 5476-5484.



(a) (b)

Fig. 1. Scanning electron micrographs obtained from cryogenically fractured cross-section surfaces of the PP-SAN (20/80) blend compatabilized with the PP-g-SAN copolymer: (a) 0 phr; (b) 1.0 phr.

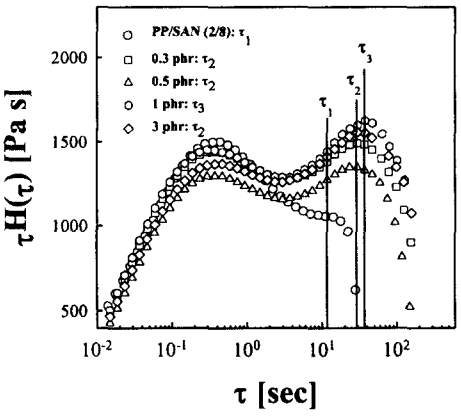


Fig. 2. Weighted relaxation spectrum of the PP-SAN (20/80) blend with the PP-g-SAN copolymer concentration: 0-3.0 phr

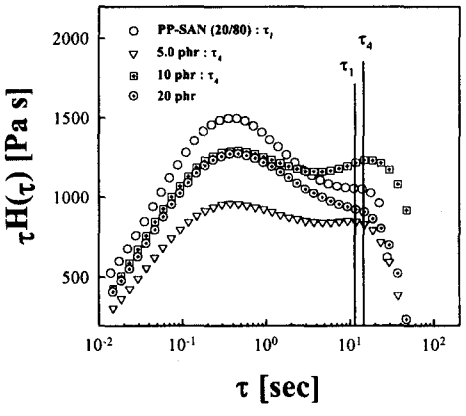


Fig.3. Weighted relaxation spectrum of the PP-SAN (20/80) blend with the PP-g-SAN copolymer concentration: 5.0-20 phr