

EFFECTS OF STYRENE-ETHYLENE/PROPYLENE DIBLOCK COPOLYMER (SEP) ON THE COMPATIBILIZATION OF PP/PS BLENDS*

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Abstract The effects of styrene-ethylene/propylene (SEP) diblock copolymer on the morphology and mechanical properties of polypropylene/polystyrene (PP/PS) blends were investigated. The results showed that SEP diblock copolymer, acting as a compatibilizer in PP/PS immiscible blends, can diminish the coalescence of the dispersed particles, reduce their average particle size, change their phase morphologies significantly, and increase the mechanical properties. It was found that SEP has better compatibilization effects on the PP/PS (20/80) blends.

Key words Polypropylene, Polystyrene, Compatibilization, Blends

INTRODUCTION

Physical blending of two or more immiscible polymers usually leads to the formation of multiphase systems with different morphologies which depend on: composition of the blends^[1], viscosity ratio of the components^[2], interfacial tension between two phases^[3], and processing conditions of the blends^[4–6]. The addition of compatibilizers can modify the interactions between different polymers and, also affect the morphology of the blends. Compatibility of the immiscible polymers can be improved by the addition of a suitable compatibilizer, *i.e.* block or graft copolymers. An effective compatibilizer, which is located in the interface between two polymers, can improve the interfacial adhesion, increase the stability against coalescence by reducing the interfacial tension^[5], facilitate the better transfer of stress across the interface and improve the mechanical properties of the blends.

Polypropylene/polystyrene (PP/PS) blends are immiscible. In order to secure good mechanical properties of these blends, the phase structure and adhesive forces between the two phases have to be well controlled. Adewole^[7] studied the effects of a graft copolymer (PP-g-PS) on the crystallization behavior and mechanical properties of the PP/PS blends.

In this paper the influence of styrene-ethylene/propylene diblock copolymer (SEP) on the morphology of PP/PS blends was studied by scanning electron microscopy. The relationship between morphology and mechanical properties was discussed.

EXPERIMENTAL

Materials

The materials used in the study were PS (Dow Styron 685) from Dow Chemical Co. and PP (FroFax 6823) from Hercules Inc. The commercial compatibilizer was SEP (Kraton G1702) obtained from Shell Co.

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Blend Preparation

Blends of the different composition were prepared by melt blending in a Brabender PL2000 chamber at 200°C for 8 min with a rotor speed of 100 r/min.

Scanning Electron Microscopy (SEM)

A Jeol FSM-840 Scanning Electron Microscope was used to study the morphology of the blends. In order to improve phase contrast between the two phases, the PS phase in the specimen was further etched using 2-butanone or exposed to RuO₄, and then coated with a thin layer of gold.

RESULTS AND DISCUSSION

The relationship between torque and compatibilizer SEP contents in the PP/PS blends is shown in Fig. 1. The torque values of PP/PS blends with weight ratio of 80/20, 60/40 and 40/60, respectively, show no obvious changes with the addition of SEP. For PP/PS (20/80) blends, the torque value was 377.7 without SEP, and increased with increasing the concentration of SEP, and reached to 653.0 at 10 wt% SEP. The results show that SEP has little effect on the viscosity of PP/PS blends with weight ratio of 80/20, 60/40 or 40/60, but exerts strong effects on that of PP/PS (20/80) blend, indicating that compatibilizer SEP can enhance the interactions between the two phases of PP/PS (20/80) blend^[8].

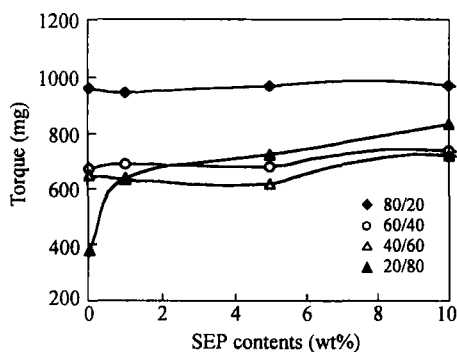


Fig. 1 Relationship between torque and the SEP contents in the PP/PS blends

Figure 2(a) shows a SEM micrograph of PP/PS (80/20) blend. The PS particles dispersed in uncompatibilized blends have an irregular shape, a broad size distribution and a smooth surface. Figure 2(b) shows a SEM micrograph of the PP/PS (80/20) blends containing 1 wt% compatibilizer SEP. Significant decrease in the particle sizes is evidenced. The particles sizes were decreased continuously with increasing SEP contents, and became more uniform at about 5 wt% SEP.

Figure 2(e) shows a SEM micrograph of PP/PS (60/40) blend, the shapes of dispersed PS phases in the uncompatibilized blend are irregular and form an incomplete continuous phases. After adding 1 wt% compatibilizer SEP, the particle sizes were decreased but the shapes were still irregular (Fig. 2f). When the amount of SEP was increased to 5 wt%, the dispersed phases became elliptical in shape. At 10 wt% of SEP, the dispersed phases in the PP matrix turned into spherical shapes and the sizes of the particles underwent little change.

Figure 2(i) shows a SEM micrograph of PP/PS (40/60) blend, part of PS phase merged into continuous phase. After adding 1 wt% of compatibilizer SEP, the PS phase shrank to smaller size (Fig. 2j). When 5 wt% of SEP was added, the particles shrank further in the blend. The “composite droplet” or “sub-inclusion” morphologies, which describe droplet-within-droplet blend morphologies, were seen (Fig. 2k). This type of structure is well known for high-impact polystyrene, which is composed of a polystyrene matrix and a rubber minor phase containing a large proportion of polystyrene subinclusions. At 10 wt% of SEP, the “composite

droplet” became smaller and more uniform. (Fig. 2l).

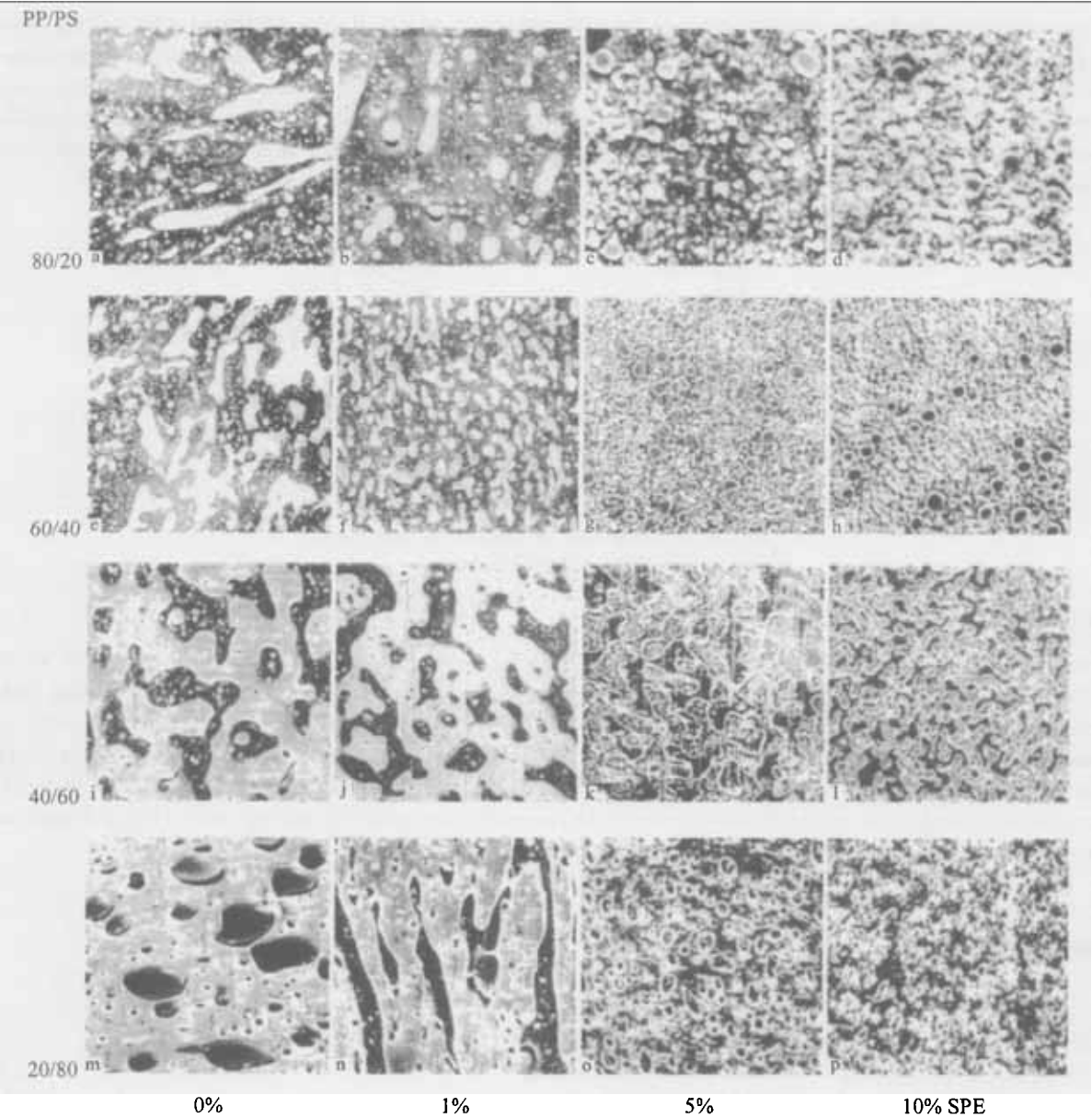


Fig. 2 SEM micrograph of PP/PS blends with and without SEP (Magnification × 2000)

Figure 2(m) shows a SEM micrograph of PP/PS (20/80) blend, the PP dispersed phase dispersed in PS matrix of uncompatibilized blend was uneven in shape and size with clean surface. The spaces between PP and PS phases can be seen very clearly. After adding 1 wt% of compatibilizer SEP, the shape of PP dispersed phase was elongated in the PS matrix (Fig. 2n). At 5 wt% of SEP, the dispersed phase was distributed evenly in the matrix and the size of the particles was reduced significantly, while the interphases between PP and PS were blurred (Fig. 2o). When the amount of SEP was increased to 10 wt%, the particles of dispersed phases became much finer and more even, and were well distributed in the matrix, the interphase between PP and PS showed more blurring (Fig. 2p).

Figure 3 shows the effects of SEP concentration on the tensile strength and impact strength of the PP/PS (20/80) blends. The tensile strength and impact strength of the blends were increased with the increase of SEP concentration. The tensile strength reached its maximum at 5 wt% SEP, and decreased after adding more compatibilizer, but impact strength continued to increase in the experimental range. At 10 wt% of compatibilizer SEP, the impact strength of PP/PS (20/80) was increased by six-fold and the compatibilization effects were obvious. Compatibilizing effects of compatibilizers depend on their distribution in the interphases. Suitable amount of compatibilizers can achieve a good effect, but only a limited amount of compatibilizer can reach the interface and leave some remains in the bulk phase as "micelles" and play the role of impact modifier.

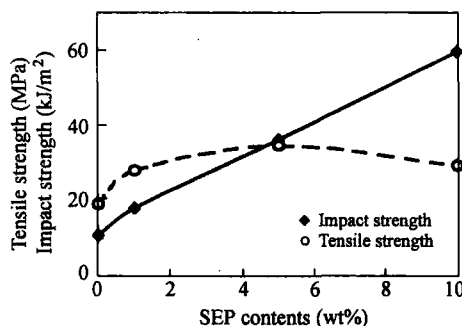


Fig. 3 Effects of SEP contents on the mechanical properties in PP/PS (20/80) blends

CONCLUSIONS

Styrene-ethylene/propylene diblock copolymer (SEP) is a good compatibilizer for PP/PS blends. In PP/PS (20/80) blends, the tensile strength reached its maximum at 5 wt% SEP, and decreased after adding more compatibilizer, but its impact strength continued to increase in the experimental range. At 10 wt% of compatibilizer SEP, the impact strength of PP/PS (20/80) was increased six-fold and the compatibilization effects are obvious. Therefore, when compatibilizers are used, aside from the consideration of the influencing factors of composition, molecular weight, microstructure of the compatibilizer, a suitable mixing ratio of two polymers has to be selected in order to achieve better compatibilization effects.

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