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Preparation and Properties of Polystyrene/SEBS Blends with Compositional Gradients in Their Sheet Direction

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Summary: There have been a few reports that discussed polymer blends with compositional gradient in their sheet directions. Thus, we discussed the preparation of the graded polystyrene(PS)/styrene-hydorogenated butadiene- styrene block copolymer(SEBS) blend with compositional gradient in their sheet directions, by applying of the solution-diffusion method. Then, the hardness on the air side surface of the graded blend gradually increased with shifting the measured point from the edge containing lowest PS content. All of the areas, into which the graded blend sheet was divided, were almost equal in length, when total elongation was 6.6 mm. However, the length of the area became longer at the larger SEBS content, when the total elongation was 175 mm. The ratio of the length of the area to that in lowest SEBS content increased gradually with increasing of SEBS content, when the total elongation became over 50 mm. It was considered that this phenomenon occurred, because of the compositional gradient in the PS/SEBS graded blend.

Keywords: blends; graded materials; hardness; PS; SEBS; tensile property

Introduction

There have been some reports of functionally graded polymer blends[1–4]. Then, we have investigated several types of the polymer blends with compositional gradient in their thickness direction, which have new properties caused by the compositional gradients (strong bonding strength, preventing of the warp, promoting of biodegradation rate, etc.)[2,3]. However, a few reports discussed polymer blends with compositional gradient in their sheet directions (Figure 1)[5]. Then, it was reported that LCST(Lower critical saturated temperature) behavior could be graphically represented, while the graded structure in the report have not caused new properties. However, it is expected in those graded blends to observe new properties caused on those graded structure.

In this study, we prepared the graded Polystyrene(PS) /SEBS blend with compositional gradient in their sheet direction (Figure 1), by applying of the solution-diffusion method, then discussed that mechanical properties (hardness and tensile elongation behavior).

Experimental

Sample films were prepared by the following method, as indicated in Figure 2: SEBS (DYNARON8601P, styrene- hydorogenated butadiene-styrene block copolymer, MFR(503 K, 21.1 N) = 3.5 g/min, styrene content = 15%) and PS (HighmerST95; Mw = 4310, Mn = 1420) were supplied by JSR co. Ltd and Sanyo Chemical Ltd respectively. SEBS was dissolved in toluene (2.5 wt%). Casting was done on a stainless tray inclined with several types of angle, at room temperature. Toluene solutions

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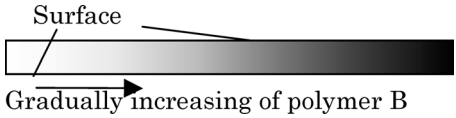

Figure 1.
Schematic model of A/B polymer graded blend in the sheet direction.

containing different concentrations of PS/SEBS(blend ratio = 1/1) were then poured on the cast SEBS film with changing of that thickness in the inclined direction, in the bat at room temperature. SEBS became dissolved and diffused in the PS/SEBS solution, until the solvent was completely evaporated. We measured Raman spectra on one surface side and the other by using a conforcal Raman spectroscopy(Senturion SURE_-CAL(CHROMEX Co.)), after the formed film was pulled off from the stainless tray.

The hardness was measured with Shore A hardness tester. The tensile test was performed at 50 mm/min. The distance of the gripes was 70 mm. Straight lines were drawn in parallel with each other on the surface of the test film. The distance of the parallel lines was 1 mm. The tensile elongation behavior was observed with a digital camera.

Results and Discussion

Preparation Conditions for Forming of Graded Structure in the Sheet Direction

We prepared several types of graded PS/SEBS blends with widely compositional gradient, by changing various types of conditions (slope angle, solution volume, and preparation temperature). Here, we prepared SEBS/PS homogenious blend with the ratio of 2/3. This film was too brittle to be used for the elongation test. Thus, the graded blend was prepared by using toluene solution of SEBS/PS blend(1/1).

Thus, it was found that widely gradient structure could be obtained by applying of solution-diffusion method. The compositional gradient in a example of excellently graded PS/SEBS blends was shown in Fig. 3. PS content on the air side surface of this PS/SEBS graded blend increased with shifting the measured point from one edge, then was kept a constant around the other edge. PS contents on the stainless tray side surface of the graded blend almost agreed with the ones on the air side over all range of the distances. Thus, it was considered that PS content in the graded blend was kept a constant in the thickness direction.

Effect of Compositional Gradient for Mechanical Properties

We measured the mechanical properties of the PS/SEBS graded blend with the compositional gradient shown in Figure 3.

The hardness on the air side surface of the graded blend gradually increased with increasing of shifting the measured point from one edge, as indicated in Figure 4. The changing curve in that hardness was almost similar to that of the PS content. Thus, it was considered that this phenom-

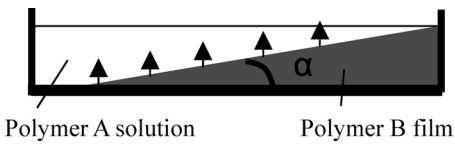

Figure 2.
Mechanism of formation of graded structure in the sheet direction.

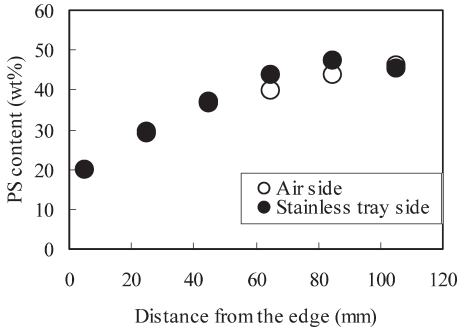

Figure 3.
PS content at several types of distances from an edge of the PS/SEBS graded blends.

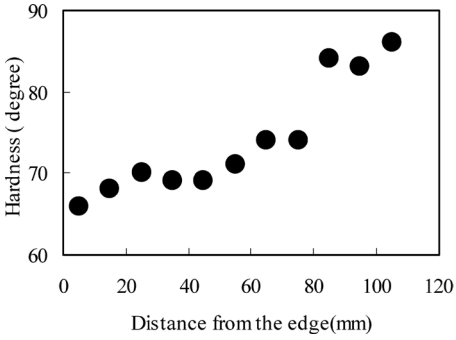

Figure 4.
Hardness at several types of distances from the edge of the PS/SEBS graded blends.

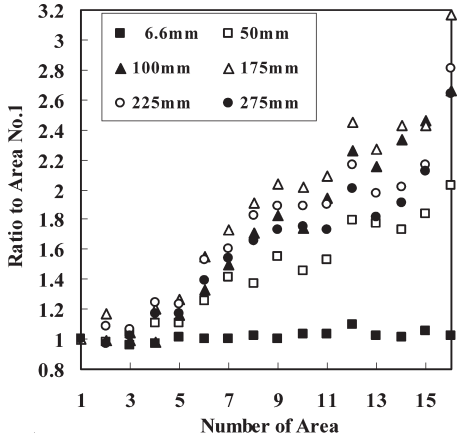

Figure 6.
Ratios of several types of number areas to No. 1 in several types of the total elongations.

enon occurred because of the compositional gradient.

The tensile elongation behavior was measured for that graded blend. The sample sheet was divided at the parallel lines into the areas named from No.1 to No. 16, as shown in Figure 5. All of those areas were almost equal in a length, when total elongation was 6.6 mm. However, the length of the area became longer at the larger SEBS content, when the total elongation was 175 mm. Then, the ratios of the lengths of the areas in several types of number to that in No. 1 were estimated, in several types of the total elongations(Figure 6). The ratio of the length of the area to that in lowest SEBS content(No. 1) increased gradually with increasing of SEBS content, when the total elongation became over 50 mm. Then the ratio in highest SEBS content(No.16) was largest, when the total elongation was 175 mm. This phenomenon occurred because of those compositional gradient, as the following. The stresses in all of the areas were equal in the tensile test. Then, the elongation became larger with gradual decreasing of the content of PS with higher elastic modulus.

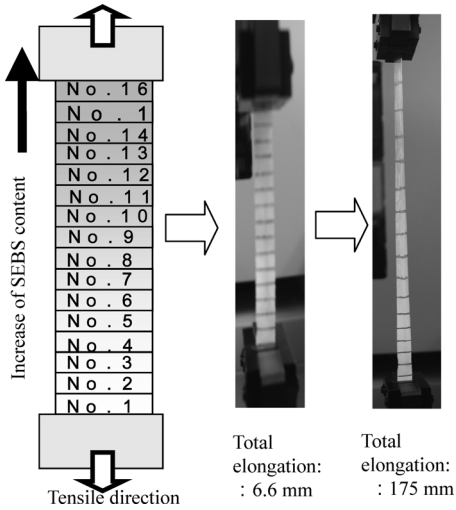

Figure 5.
SEM observations of tensile elongation behaviors of several types of the number areas named as No. 1– 16, when the total elongation was 6.6 or 175 mm.

Conclusion

It was found that graded PS /SEBS blend with compositional gradient in the sheet direction could be prepared by applying of the solution-diffusion method. The hardness on the air side surface of that graded blend gradually increased with shifting the measured point from the edge containing lowest PS content. All of the areas, into

which the graded blend sheet was divided, were almost equal in length, when total elongation was 6.6 mm. However, the ratio of the length of the area to that in lowest SEBS content increased gradually with increasing of SEBS content, when the total elongation became over 50 mm. It was considered that these phenomenon occurred because of the compositional gradient in the PS/SEBS graded blend.

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