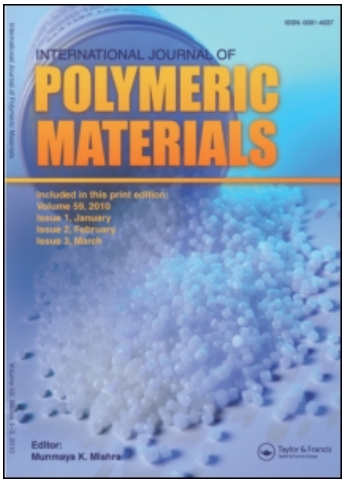

International Journal of Polymeric Materials
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713647664

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To cite this Article Yan, R. Jiang , Li, W. , Chen, C. , Zhang, H. , Jiang, B. and Yang, B.(1993) 'On the Phase Structure of Blends of Polycarbonate with Poly(acrylonitrile-butadiene-styrene)', International Journal of Polymeric Materials, 23: 1, 109 — 113
To link to this Article: DOI: 10.1080/00914039308009662
URL: http://dx.doi.org/10.1080/00914039308009662

Intern. J. Polymeric Mater., 1993, Vol. 23, pp. 109–113
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Printed in Malaysia

On the Phase Structure of Blends of Polycarbonate with Poly(acrylonitrile-butadiene-styrene)

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(Received June 25, 1993)

Polycarbonate (PC) and poly(acrylonitrile-butadiene-styrene) (ABS) was co-extruded at different weight ratios by a single screw extruder. In order to obtain a finer blend, two times extrusion was carried out. In this case, a "network" structure with two-continuous phases was observed for the blends with two compositions of PC/ABS, being 80/20 and 70/30. It is found that the blends with these two compositions just have maximum values on the curves of notched Izod impact strength, flexural modulus and flexural strength vs. composition, respectively. This was never observed in previous publications.

KEY WORDS ABS, blends, polycarbonate, properties, phase structure

1. INTRODUCTION

Polycarbonate (PC) and poly(acrylonitrile-butadiene-styrene) can be blended to form into plastic alloy with excellent properties.[1,2] Many researchers have studied various properties (including some mechanical properties, some melt properties, and some thermal properties) of various compositions of PC/ABS blends.[3–6] The influence of reprocessing on physical properties of PC/ABS blends[7] and the weathering of several commercial PC/ABS alloys have also been studied.[8]

In an early paper, Stefan and Williams[9] observed the morphology of one commercial PC/ABS (50/50) blend by SEM and transmission electron microscopy (TEM), and found that PC phase was discontinuous, ABS phase continuous. In the study of morphology by SEM for the single screw extruded ABS/PC blends, Kim and Burns[6] observed the continuous phase and the dispersed phase for all the compositions. In a recent paper, phase morphology of injection-molded PC/ABS blends was examined by SEM across the entire composition range.[10] The SEM was also used to study the morphology of fracture surfaces of impact[5] and tensile specimens.[7]

This communication reports the results of morphology study on PC/ABS blends, which is different from all the above observations.

2. EXPERIMENTAL

ABS resins used were ABS 301 made by Lanzhou Chemical Industry Co., China. Composition: 22.8 percent acrylonitrile, 22.2 percent butadiene, 55.0 percent styrene, MFI = 1.5 at 200°C/5 Kg. Polycarbonate (PC) pellets used were PG-2y made by Changzhou Organic Chemical Plant, China, and were of a standard grade of medium melt viscosity with M_w = 30,000.

The various compositions of PC/ABS were compounded at the weight ratios of 0/100, 40/60, 50/50, 30/70, 60/40, 70/30, 80/20 and 100/0, and then they were blended in the Brabender Single Screw Extruder at 220°C–260°C. After they were cut into pellets, the blends were extruded again. The length-to-diameter (L:D) ratio of the screw is 30:1, the diameter of the die is 0.2 mm. The pieces for mechanical and SEM testing were prepared by compression-molding in frames with different thickness. The compounds were first preheated at 200–250°C for 7 min before they were compressed at 100 Kg/cm^2 for 5 min, and then they were taken in another hydraulic press and cooled to room temperature.

Notched Izod impact strength and flexural properties were measured by the GB 1843-80 and GB1042-79 methods, respectively. The thickness of the impact specimens was c.a. 0.4 cm.

The morphology of the cross section surfaces of compression-molded sheets was examined by SEM in a JOEL Model JXA-840 microscope after sputter coating. The fracture surfaces of the 0.5-mm thick sheets were prepared by crogenic fracturing at liquid nitrogen temperature.

3. RESULTS AND DISCUSSION

In order to observe phase structure of PC/ABS blends, SEM micrographs were obtained from crogenically fractured cross-section surfaces of compression-molded sheets, as shown in Figure 1. In the fractured surface of pure ABS (Figure 1a), we see a lot of small holes, which are the positions occupied by the butadiene in ABS before the sample was fractured. When ABS is blended with PC at the two compositions of PC/ABS, 80/20 and 70/30, the "network" structure with two-continuous phases is observed in the micrographs (b) and (c).

For the blends of PC/ABS with compositions of 60/40 and 50/50, Figures 1d and 1e reveal one dispersed phase and another continuous phase although the dispersed phases in Figure 1d also tend to be continuous. To identify which of the two phases is ABS or PC, SEM micrograph with a higher magnification is presented in Figure 1f for the PC/ABS (60/40) blend. It shows that some small holes similar to but with less sizes than those in Figure 1a exist in the continuous phases, indicating that the continuous phase is ABS, the discontinuous phases are PC. These results in Figures 1d and 1e are consistent with the observation on the commercial PC/ABS (50/50) blend by Stefen and Williams.[9]

In the study of Kim and Burns[6] on morphology of extrudates of PC/ABS blends with compositions of 90/10, 80/20, 20/80, 10/90, SEM results showed that ABS was dispersed phase and PC is continuous phase for all the compositions. The different

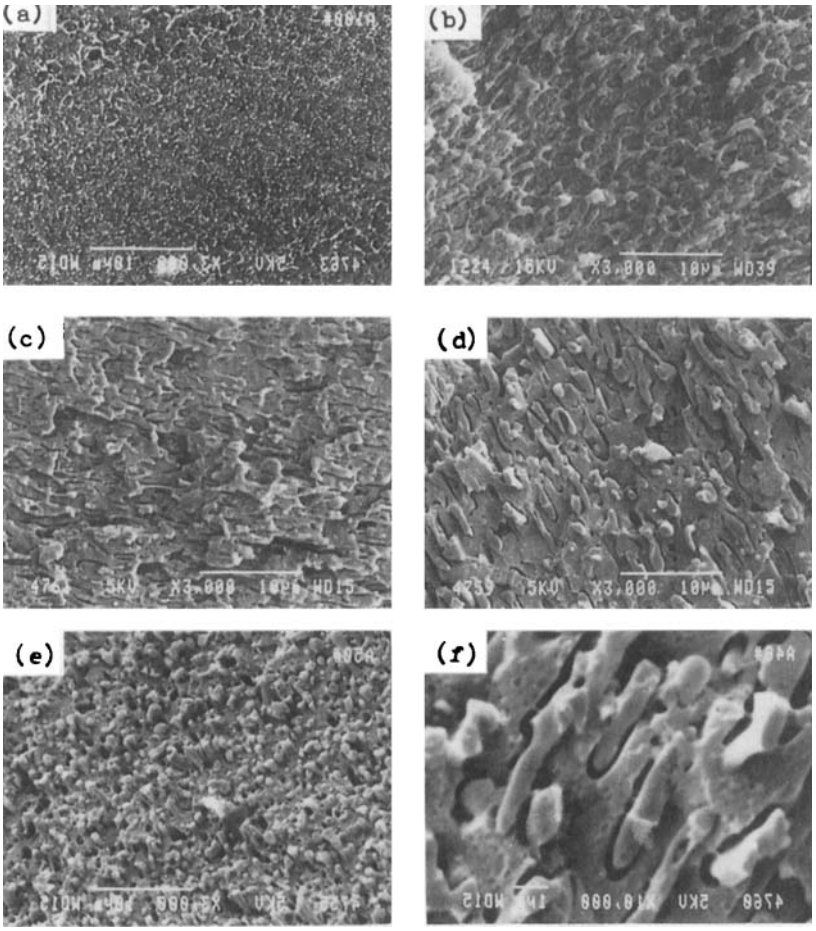

FIGURE 1 SEM micrographs obtained from crogenically fractured cross-section surfaces of compression-molded sheets for the blends of PC/ABS: (a) 0/100, (b) 80/20, (c) 70/30, (d) 60/40, (e) 50/50, (f) 60/40. Magnification: (a–e) 3000X, (f) 10000X.

results (Figure 1) obtained by us are possibly caused by the difference of processing and/or the difference of the used extruders. It is easily understood that the blending effect is poor for polymer compounds blended only by one time extrusion of a single screw extruder, as done by Kim and Burns.[6] Therefore, PC and ABS compounds were extruded two times in this study, which is possibly why we obtained the structure of two-continuous phases for the PC/ABS blends with the compositions of 80/20, 70/30.

Generally speaking, the change in structural morphology of materials will be reflected in their properties. To make us further understand the relationship between structure and properties of PC/ABS, the notched Izod impact strength, and the flexural modulus and flexural yield strength were plotted vs. compositions of PC/ABS blends in Figure 2 and Figure 3. The two curves of impact strength measured at 22°C and at −40°C have maximums when the composition of PC/

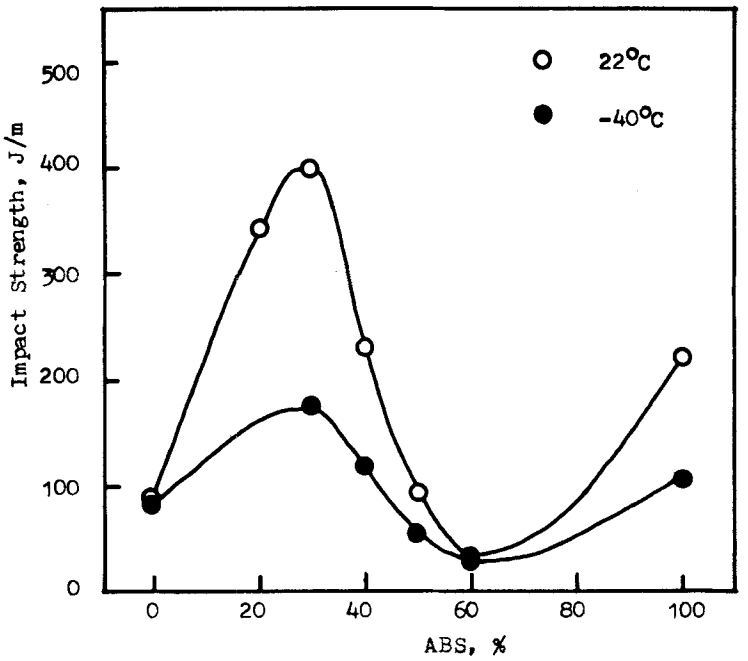

FIGURE 2 Dependence of notched Izod impact strength of PC/ABS blends on percentage of ABS in the blends.

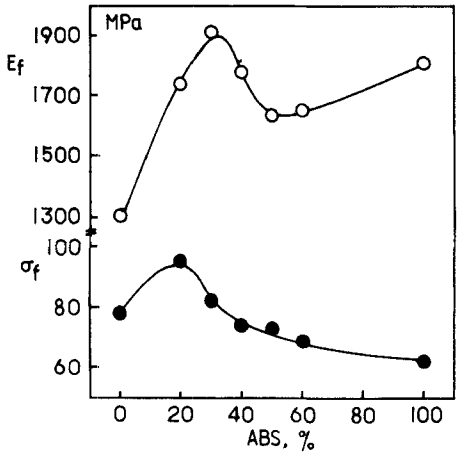

FIGURE 3 Dependence of flexural modulus E_f, flexural yield strength σ_f of PC/ABS blends on percentage of ABS in the blends.

ABS is equal to c.a. 70/30 or between 80/20 and 70/30, and they have minimums when the composition is equal to c.a. 40/60. The values of the notched impact, especially measured at 22°C, are much higher than that of ABS and PC themselves. On the other side, the flexural modulus and flexural yield strength of the blends, respectively, have a maximum for PC/ABS blends with compositions of 70/30 and

80/20. These results imply that the PC/ABS blends should have special structure at the compositions of 80/20 and 70/30, which is identical with the observed structure with two continuous phases in Figure 1.

In a study on compression molding PC/ABS blends,[5] it was reported that two continuous phases appear in the impact fracture surface of PC/ABS (50/50) blend, and this blend has poorer impact strength than the blends with other compositions, which is contrary to our results and the observation of Stefan and Williams.[9] We believe that the phase morphology of PC/ABS blends could not be perfectly observed in surfaces of impact specimens fractured at room temperature.

CONCLUSIONS

PC and ABS, when co-extruded two times at a single screw extruder, can form into the blend with a structure of two continuous phases (or "network") at the PC/ABS compositions of 80/20 and 70/30. The blends with these two compositions have maximums in the curves of notched impact strength, flexural modulus and flexural strength vs. composition, respectively, and the notched impact strength at the maximum point is much higher than that of PC and ABS themselves.

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