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# Morphology and mechanical property of the polycarbonate/poly(styrene-co-acrylonitrile) blend containing poly(ε-caprolactone)

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## SUMMARY

The morphology and the mechanical property of polycarbonate(PC)/poly(styrene-co-acrylonitrile)(SAN) blends containing poly(ε-caprolactone)(PCL) as a compatibilizer were investigated. For the study, blends of various composition were prepared by melt blending using a twin-screw extruder. Fracture surface of the blend was observed using scanning electron microscope. The domain size of discrete phase decreased with increasing PCL content in the blends. Tensile strength of the blends showed maximum but elongation at break and notched Izod impact strength of the blend increased with increasing PCL content. Physical implications of the phenomena are discussed.

## INTRODUCTION

In the past decades, the structure-property relationships of various polymer blends have been the subject of growing interest. Much attention has been paid to miscibility, morphology, and mechanical properties of polymer blends. Many polymer blends are immiscible and relatively few polymer blends are miscible. Thus, addition of compatibilizer to improve compatibility of immiscible blend is one of the methods to develope useful polymer blends.

Blends of polycarbonate(PC) / poly(styrene-co-acrylonitrile) (SAN) have been reported to be partially miscible by many researchers(1,2). Mechanical properties such as elongation at break and impact strength of the blend fall off rapidly at 10 wt % of SAN and greater because of limited compatibility. It is of interest to note that blends of PC/poly (ε-caprolactone)(PCL) and SAN/PCL are miscible according to previous studies(3,4). Therefore, it is expected that PCL may be a compatibilizer for the PC/SAN blend. Paul and his coworkers studied blends of PC/SAN/PCL and reported that the ternary blend became miscible as the content of PCL was increased, based on the glass transition temperatures of the system(5).

Recently, we have carried out experimental studies on the characteristics of PC/SAN blends containing PCL as a compatibilizer. In this paper, morphology and mechanical properties of the blends investigated are discussed.

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## EXPERIMENTAL

Three commercial polymers were used in this study. These were (i) polycarbonate (PC)(General Electric Lexan 141), (ii)poly(styrene-co-acrylonitrile)(SAN)(Hannam Chemical Hanasan-300) , and (iii)poly($\epsilon$-caprolactone)(PCL)(Union Carbide Tone-700). The acrylonitrile content of the SAN used are known to be 25 % by weight.

According to the previous studies by Paul and his coworkers, the amount of PCL required to solubilize the blend of 50% PC/50% SAN is larger than that required to solubilize the blend of 25% PC/75% SAN or the blend of 75% PC/25% SAN(5). Thus, we chose the blend of 50% PC/50% SAN in order to study the effects of PCL on the properties of PC/ SAN blend. Ternary blends of PC/SAN/PCL were prepared using a twin screw extruder( TEX-30, Japan Steel Workers Ltd.). The contents of PCL were 5,10,15,20,25,and 33 % by weight in the blends in which the ratio of PC/SAN were fixed 50/50 by weight.

The blends were injection molded for tests of tensile strength, elongation at break,and notched Izod impact strength according to ASTM D638 and D256. Fracture surfaces of the specimens after the impact strength tests were coated with gold in vacuum and were observed using scanning electron microscope (SEM) (Hitachi X-650). Light transmittance of injection molded specimen of thickness 3.2 mm was measured using direct reading hazemeter(Toyoseiki Seisakusho). Thermal property of the blends was studied employing differencial scanning calorimeter(DSC:DuPont 910).

## RESULTS AND DISCUSSION

In Fig.1, the tensile strength and the elongation at break of the PC/SAN blend containing PCL as a compatibilizer are shown. It is seen that the tensile strength of the blend shows maximum and the elongation at break increases as the content of PCL is increased. It is of interest to note that tensile strength of the blend increases with the PCL content in the blend up to 15 %, eventhough the tensile strength of PCL is lower than those of PC and SAN. MacKnight et al. pointed out that compatible blends show a small maximum in tensile strength over certain blend compositions(6). It is speculated that the synergism in tensile strength observed similar to compatible blends is attributable to improved compatibility of PC and SAN and better molecular packing by virtue of PCL in the blends. In Fig.2, notched Izod impact strength for the blend of different PCL content is given. It is seen that the impact strength increases very much when the content of PCL in the blends is higher than 20 %. The beneficial effects of PCL on impact strength may also be attributed to the improved compatibility between PC and SAN in the blend.

In Fig.3, SEM pictures of fracture surfaces of the blends are given. The continuous and the discrete phase are observed for all compositions in Fig.3.

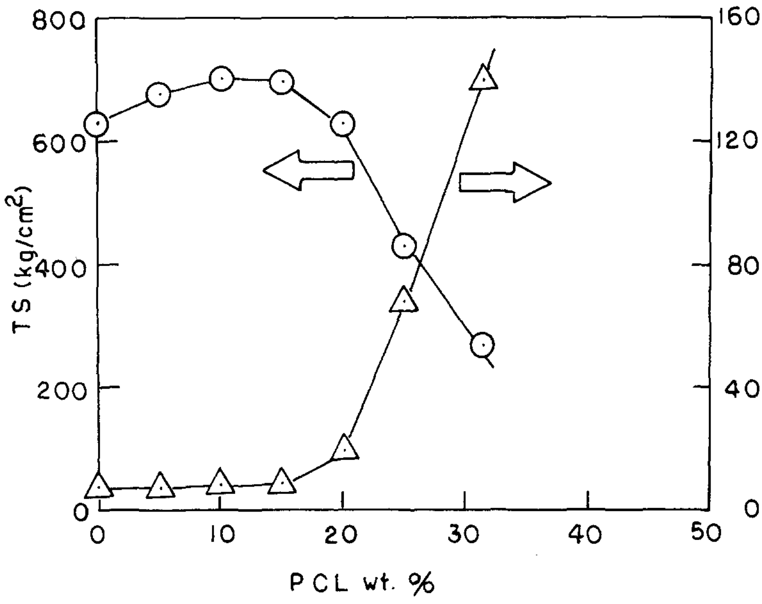


Fig.1. Tensile strength(TS) and elongation at break(EL) versus PCL content for the PC/SAN(50/50) blends.

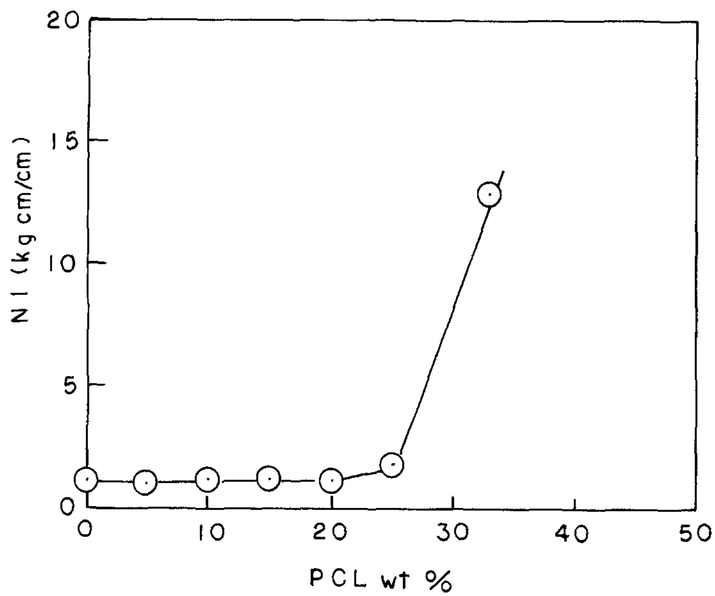


Fig.2. Notched Izod impact strength(NI) versus PCL content for the PC/SAN(50/50) blends.

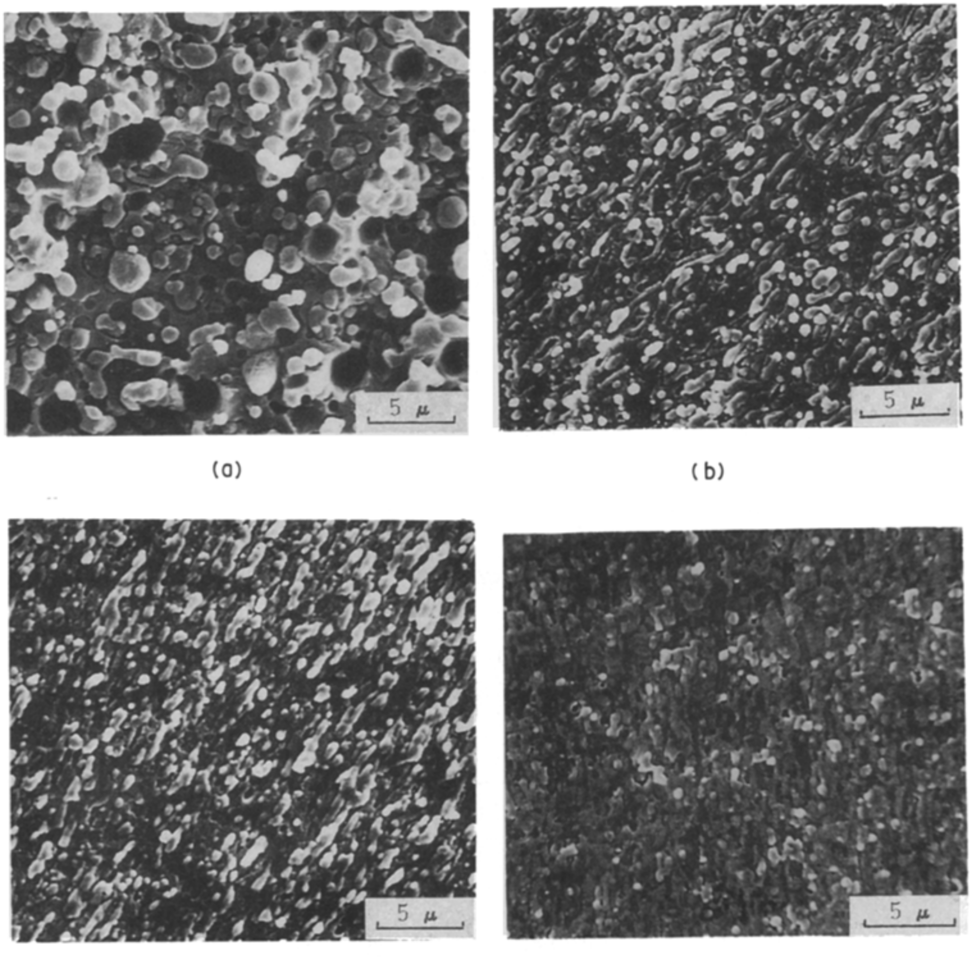


Fig.3 Scanning electron micrographs of PC/SAN(50/50) blends containing various amount of PCL(% by wt) at magnification of 3,000:(a)0;(b)10;(c)20;(d)33.

Morphology of polymer blends depends on the composition, mixing conditions, and interfacial tension of the polymers. According to Oene, when the viscosity of one polymer in discontinuous phase is lower than that of the other polymer in continuous phase, stratification is observed while dispersion of droplets is observed in opposite cases(7). As PC has a higher viscosity than SAN in general, it is speculated that the discrete phase in Fig.3 is PC rich. The domain size of discrete phase decreases as the content of PCL is increased in the blends. It seems that interfacial tension between PC and SAN is lowered by adding PCL which is miscible both with PC and SAN in the blends and the domain size of the descrete phase decreased. The adhesion between PC and SAN is believed to be improved as the content of PCL is increased in the blends.

In Fig.4, light transmittance of the injection molded tensile test specimen of the blends are shown. It is observed that the light transmittance of the blend shows maximum with increasing PCL content in the blends. Transparency of heterogeneous blend depends on the domain size and the difference in refractive indices of the constituents. Rosen indicated that the critical domain size for transparency of heterogeneous blend is approximately 0.1 $\mu$ (8). According to Bohn, the critical difference between refractive indices should be less than 0.01 for transparency (9). The domain size of the PC/SAN blend in Fig.3 is not small enough to become transparent. The refractive indices of PC and SAN are 1.585 and 1.570 respectively and the difference in refractive indices is not small enough for transparency of the blend. Thus, it is suggested that light transmittance of the blends increases due to the closed refractive indices of PC and SAN with increasing the PCL content up to 20%. It is of interest to note that light transmittance of the blends decreases as the PCL content is more than 20%. This phenomenon is attributable to crystallization of PC induced by PCL and PCL itself. The presence of crystallinity in the blend was confirmed by DSC as shown in Fig.5. The crystallinity was seen by weak endothermic melting peak at 65 °C and 225 °C due to PCL and PC respectively. It is suggested that the transparency of the blends can change depending on crystallinity.

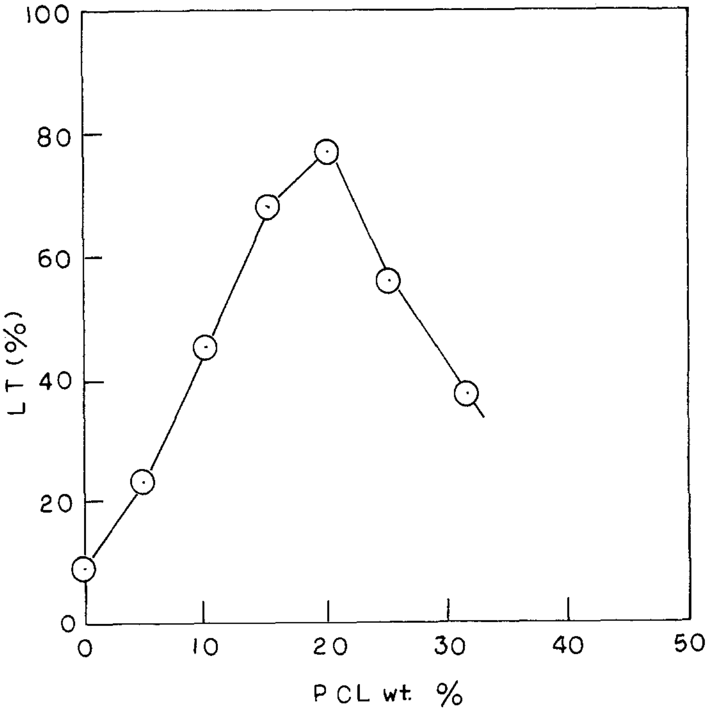


Fig.4 Light transmittance(LT) versus PCL content for the PC/SAN(50/50) blends.

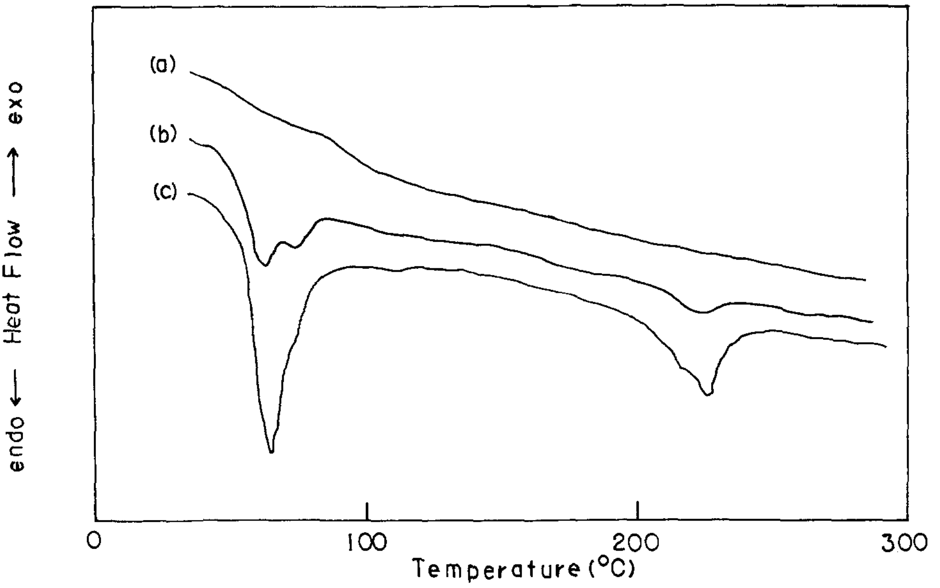


Fig.5 DSC thermogram of PC/SAN(50/50) blends containing various amount of PCL (% by wt):(a)20;(b)25;(c)33.

## CONCLUSION

Improvement of compatibility of the PC/SAN blends containing PCL as a compatibilizer was confirmed by mechanical property and morphology. Tensile strength showed maximum while impact strength and elongation at break increased with increasing PCL content in the blend. The domain size of discrete phase decreased with increasing PCL content in the blends. Additions of PCL to the PC/SAN blends increased the light transmittance of the blends due to improved compatibility initially, but further additions of PCL decreased the light transmission because of crystallization of PCL and PC in the blends.

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