# In-Situ Compatibilization of PC/SAN Blend by High Intensity Ultrasound

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# 고강도 초음파를 이용한 PC/SAN 블렌드의 상용화

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## Introduction

High intensity ultrasounds are generally employed in the areas of cleaning, plastic welding, matching, etc. In addition to these conventional applications, numerous studies have suggested a new possibility as useful way to include mechano-chemical degradation in polymeric materials.[1-2] It is expected that cleaving bonds can create reactive macroradicals, so this leads to an important consequence since in-situ copolymer formation is an efficient path to compatibilize polymer blends and stabilize their phase morphology in the absence of other chemical agents.[3]

Blend of PC and ABS is a commercially important material in fabrication of various parts for automobiles and appliances, providing excellent toughness and heat resistance. Although desirable combination of mechanical properties is possible because of the adequate adhesion between the PC and SAN, practical problems related to non-uniform state of dispersion and unstable morphologies are often encountered in processing.[4-5]

In this study, ultrasound-aided degradation of PC and SAN was practiced during melt processing of the polymer in batch mixer. Also, we investigated the changes in the morphology of PC/SAN blends for various viscosity ratios of PC and SAN and improvement of mechanical properties of sonicated blends was evaluated.

## Experimental

The materials used in this study are all commercially available polymers and their details are summarized in Table 1. In order to impose ultrasonic wave during melt mixing, a specially designed ultrasonic horn was assembled with a Haake mixer. The horn vibrated longitudinally at a frequency of 20 kHz with an amplitude of 15 μm. A 1.5 kW power supply with a piezoelectric converter was used. Prior to mixing operation, pure resins were dried in a vacuum oven at 80℃ for 24 hours. Each sample prepared on a fixed volume basis of 70% and mixing temperature was 230℃ and blend content was fixed as 80/20(PC/SAN) by weight fraction. Before the irradiation of ultrasound, preliminary mixing was carried out for 2min to reach the molten state and the sonication time was varied as 1, 3 and 5 min. Plate-plate rheometer (ARES, Rheometrics Scientific) was used to measure the dynamic viscosities of a sonicated samples. Experiments were carried out with 25mm plate diameter, 1.5mm gap distance, 10% strain rate, and 0.1~100rad/sec frequency ranges. Morphologies of the blends were observed from scanning electron microscope (HITACHI S-2500). Materials testing machine(Lloyd Instruments LR5K) was used for the mechanical property measurement. All tests were performed at room temperature with a crosshead speed of 5mm/min. Also, in order to assure the in-situ compatibilization, the samples were put into a proper annealing procedure, where each blend was stored in an oven during 10min at 200℃.

**Result and Discussion**

Figure 1 shows the complex viscosities of PC and SAN by irradiation of ultrasonic wave. Viscosities of both PC and SAN decreased with increasing sonication time. These results provide the evidences of chain scission in PC and SAN by ultrasonic wave during melt processing. The effects of sonication time and viscosity ratio on the average domain size of the PC/SAN(80/20) blends are displayed in Figures 2 and 3, respectively and their results are summarized in Figure 4. It is observed that the increase of sonication time leads to a decrease in the average domain size for each sample, while increase in the viscosities of SAN resulted in the opposite effect. In order to examine stability of the morphology for sonicated blend, samples are annealed during 10min at 200℃, and the results are shown in Figure 5. It is clearly seen that coalescence was significantly suppressed in the sonicated blend, while considerable increase in domain size was inevitable in the blend prepared from simple mixing. The enhancement of mechanical properties of sonicated blends is clearly seen in Figure 6, where elongation at break of the sonicated blend is two times higher than that of

simple blend. It is believed that sonicated blend enhances intermolecular interaction by promoting chemical bonds between dissimilar polymers without use of any compatibilizers.

## Conclusions

By using high intensity ultrasound, it was possible to induce chain scission of the polymers in melt state without any solvents or additives. The viscosities of PC and SAN were significantly decreased by sonication. In melt mixing of the PC/SAN blend, irradiation of ultrasound led to stable morphology with reduced domain size. It was proved from the annealing experiments and mechanical testing that copolymers of PC and SAN were formed by combination of the corresponding macroradicals and consequently acted as compatibilizers for the blends. The viscosity ratios of PC and SAN played a critical role in in-situ compatibilization during sonicated mixing. It was desirable to keep the viscosity of matrix higher than that of the domain for effective compatibilization.

## Acknowledgement

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## Reference

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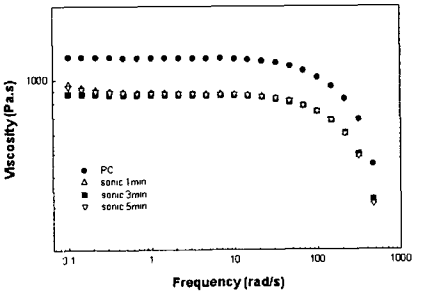
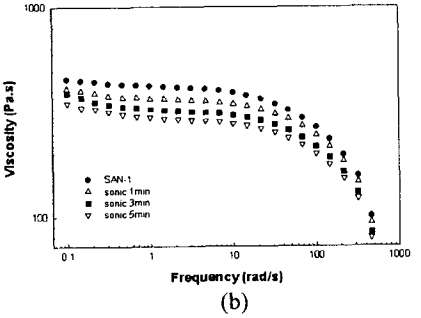
Table 1. Polymers in this study

| Polymer | Abbreviation | Source (Grade) | Molecular Weight | Copolymer composition (wt%) |
|---|---|---|---|---|
| Poly-carbonate | PC | Teijin (Panlite L1250W) | Mn=12,000 Mw=19,000 | |
| Poly (styrene-co-acrylonitrile) | SAN-1 | Cheil Ind. Inc. | Mn=42,000 Mw=69,000 | 25% AN |
| | SAN-2 | Cheil Ind. Inc. | Mn=53,000 Mw=96,000 | 24% AN |
| | SAN-3 | Cheil Ind. Inc. | Mn=91,000 Mw=170,000 | 26% AN |

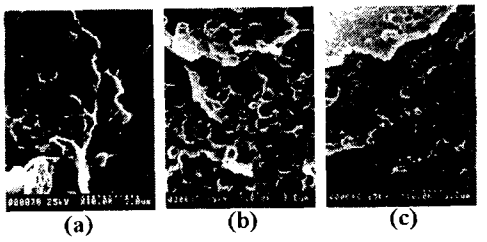



(a)



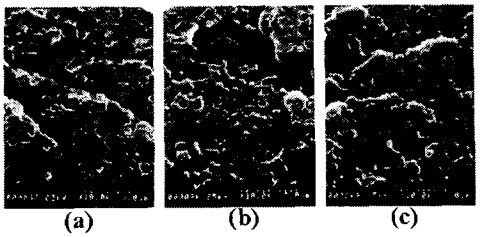

(b)

Fig.1 Effect of sonication time on the viscosity of the polymer; (a)PC (b)SAN-1



(a) (b) (c)

Figure 2. SEM images of PC/SAN-1(8/2) blends; (a)simple mixing, (b)sonication 1min, (c)sonication 3min



(a) (b) (c)

Figure 3. SEM images of PC/various SAN blends; (a)PC/SAN-1, (b)PC/SAN-2, (c)PC/SAN-3 (sonication time = 3min)

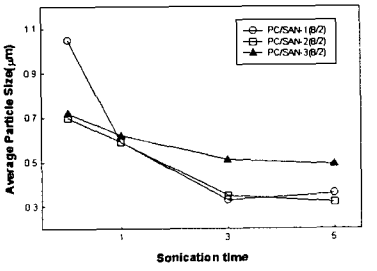
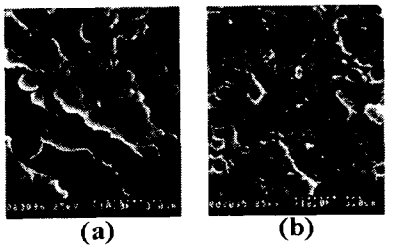



Figure 4. Effect of viscosity ratio on the average domain size of PC/SAN blends.



(a) (b)

Figure 5. Annealing test of PC/SAN-1 blends; (a)simple mixing, (b)sonication 3min

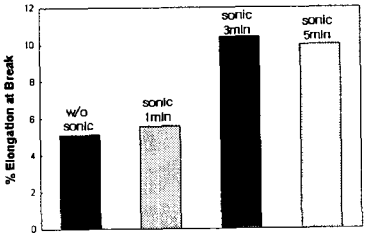



Figure 6. Percent elongation at break for PC/SAN-1 blends