

NOTE

아라미드단섬유보강 폴리에틸렌 아이오노머

최치훈·옥영숙·김병규·조원제

부산대학교 공과대학 고분자공학과

(1991년 11월 27일 접수)

Short Aramid Fiber Reinforced Polyethylene Ionomer

Chi Hoon Choi, Young Sook Ok, Byung Kyu Kim, and Won Jei Cho

Dept. of Polymer Science and Engineering, Pusan National University, Pusan 609-735, Korea

(Received November 27, 1991)

INTRODUCTION

Our earlier works dealt with the short aramid fiber reinforced polyethylene(PE)¹ and maleic anhydride(MAH)-graft-PE(g-PE).² From the SEM (scanning electron microscopy) micrographs of the fracture surfaces, good interfacial adhesion between g-PE matrix and fibers has been evidenced. However, a dilution effect caused by the elastic nature of the crosslinked g-PE was noted, and consequently tensile modulus and strength of the composite at low fiber loading were lower than the matrix. In this paper, the use of poly(ethylene-co-methacrylic acid) type ionomer(Surlyn) is considered as the matrix. With ionomer matrix, good interfacial adhesion with aramid fiber yet with no dilution effect is expected. Morphology, tensile strength and rheological properties of the composites are briefly described.

EXPERIMENTAL

Detailed procedure is described in our earlier reports.^{1,2} Kevlar 49, chopped to 5 mm, and polyethylene(PE) ionomer(du Pont, Surlyn 8528, M. I.

= 1.3 g/10 min) were used as fiber and matrix. Fibers, up to 20 wt% based on total weight, were added to Surlyn on a roll mill, at $140 \pm 1^\circ\text{C}$, with nip gap 1.5 mm and roll speed ratio, 1 : 1.20. The rolled sheets were compression molded at 120°C , 1200 psi for 10 min.

Compression molded sheets were fractured at liquid nitrogen temperature, parallel(L) and perpendicular(T) to the roll direction, and observed under SEM after sputtering with gold. Tensile tests(ASTM D-638M) were conducted with Instron tensile tester with elongational rate of 100 mm/min at room temperature. Melt properties were determined using a Rheometrics Dynamic Spectrometer (RDS II) at 230°C .

RESULTS AND DISCUSSION

Morphology

SEM micrographs of the cryogenically fractured surfaces of the composites are shown in Fig. 1. It is seen that the fiber orientation is not clear at 5 wt% fiber content, and the orientation generally increases with the increase of fiber content.^{3,4} Specimens fractured across the roll direction(L) show

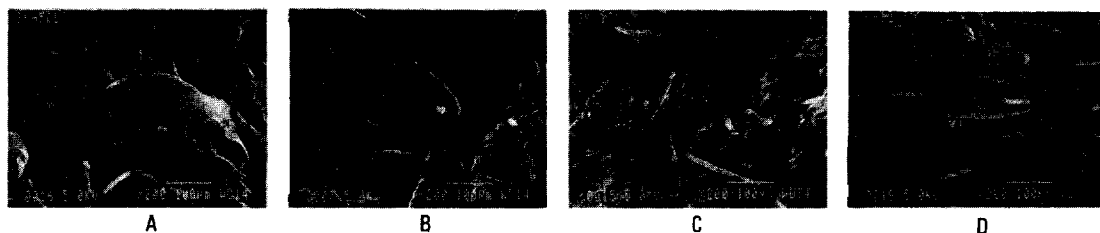


Fig. 1. SEM micrographs of cryogenically fractured surfaces of PE Ionomer/Kevlar composites.

that most fibers were fractured at the fracture surfaces, indicative of strong interfacial adhesion. Samples fractured across the T direction show fibers lying on the fractured surface. Holes left upon pollout of the fibers are also seen, but the number of holes seems insignificant.

Mechanical Properties

Fig. 2 to 4 show the mechanical properties of the composites, where tensile modulus, strength, and their anisotropy i. e., the difference in L and T directions increase monotonically with fiber content, and a rapid decrease in ductility (Fig. 4) up to 10 wt% fiber content is noticed. The linear variation of modulus and strength may imply that the fibers are well distributed in the matrix.^{4,5} Dilution effect, often observed in elastomeric^{6,7} and g-PE matrix,² was not appeared due probably to the enhanced interfacial adhesion between fiber and matrix.⁴ At lower fiber loading, there are not enough fibers to control matrix elongation, and fibers would be subjected to high strain with only small loads, and break. This is known as dilution effect. Like in PE and g-PE matrix, the property anisotropy is increased with fiber content caused by the fiber orientation, evidenced from the SEM micrographs.

Melt Properties

Fig. 5 shows the complex viscosity of the composites. Like in PE and g-PE composites, viscosity increased with fiber content, more at lower and less at higher contents. However, the tendency for viscosity yielding is suppressed up to 10 wt% and this probably comes from the satisfactory dispersion of fibers prohibiting fiber coalescence in melt state.^{4,5,8}

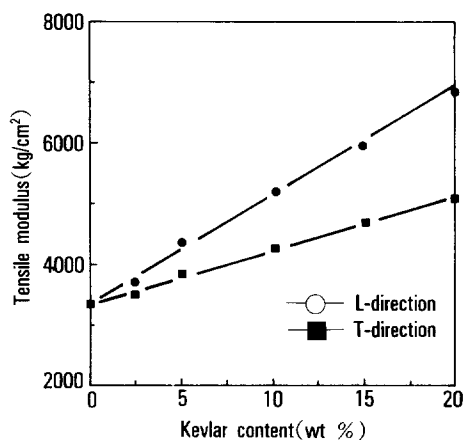


Fig. 2. Tensile modulus vs. Kevlar content for PE Ionomer/Kevlar composites.

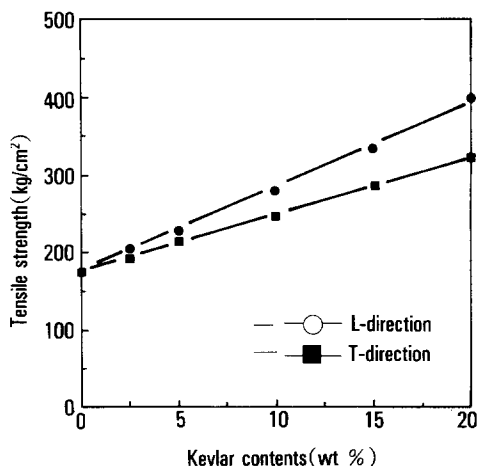


Fig. 3. Tensile strength vs. Kevlar content for PE Ionomer/Kevlar composites.

When G' was plotted against G'' (Fig. 6), a rela-

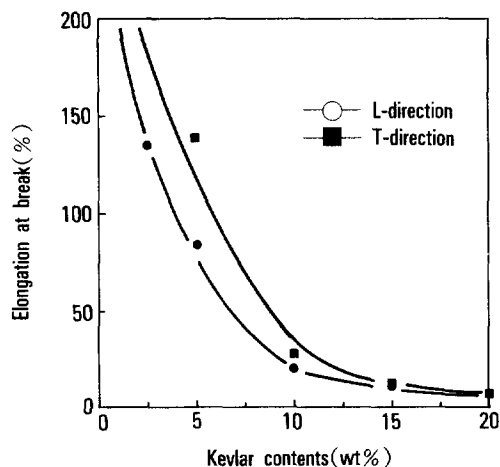


Fig. 4. Elongation at break vs. Kevlar content for PE Ionomer/Kevlar composites.

vely well defined line with little scatter of data is obtained. Since G' is a measure of melt elasticity and G'' a viscosity,⁹ the little scatter of data implies that the relative elasticity of the matrix is not significantly modified with fiber content as evidenced from the fact that the data are located above $G' = G''$ line.

CONCLUSION

Tensile modulus and strength of short Aramid fiber reinforced polyethylene ionomer (Surlyn 85 28) linearly increased with fiber content. In addition, melt viscosity as well as the solid state anisotropy gave essentially identical trend with the above properties, and the smooth variation in property could be interpreted in terms of improved dispersion of fibers in ionomer matrix.

REFERENCES

1. Y. S. Ok, C. H. Choi, Y. J. Kim, and B. K. Kim, *Polymer(Korea)*, **16**(2), 185 (1992).
2. C. H. Choi, Y. S. Ok, B. K. Kim, C. S. Ha, W. J. Cho, and Y. J. Shin, *J. Korean Ind. & Eng. Chemistry*, **3**, 81 (1992).
3. M. Takayanagi, T. Kajiyama, and T. Katayose, *J. Appl. Polym. Sci.*, **27**, 3903 (1983).
4. P. K. Mallick, "Fiber Reinforced Composites",

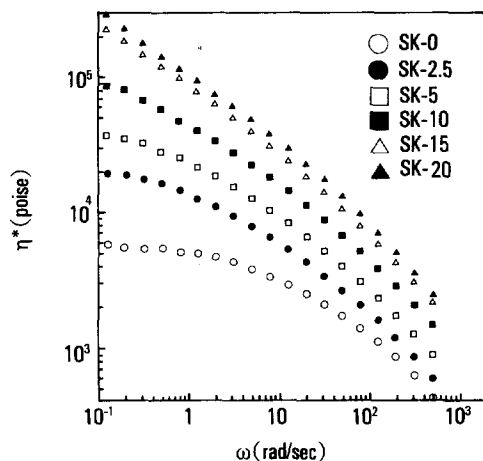


Fig. 5. Complex viscosity vs. frequency for PE Ionomer/Kevlar composites (Number designates weight % of fiber).

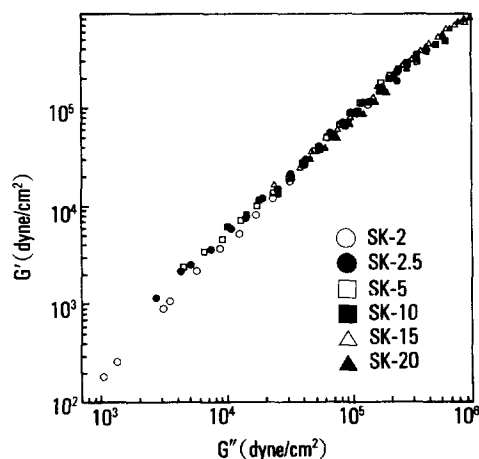


Fig. 6. Storage modulus vs. loss modulus for PE Ionomer/Kevlar composites (Number designates weight % of fiber).

Marcel Dekker, New York, 1988.

5. G. Lubin, "Handbook of Composites", Van Nostrand Reinhold, New York, 1982.
6. L. A. Goellte and K. S. Shen, *Rubber Chem. Tech.*, **56**, 619 (1982).
7. S. Abrate, *Rubber Chem. Technol.*, **59**, 384 (1986).
8. Y. Chan, J. L. White, and Y. Oyanagi, *Journal of Rheology*, **22**(5), 507 (1978).
9. C. D. Han, "Multiphase Flow in Polymer Processing", Academic, New York, 1981.