고분자 나노복합재료의 내부 구조 및 유변학적 성질

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Structural and Rheological Characterization of Polymer Nanocomposites

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1. Introduction

Polymer layered silicate nanocomposite has become an important area of polymer research becaues of its predominant properties in mechanical and thermal properties. Polymer layered silicate nanocomposites show outstanding improvements in tensile strength and modulus, heat distortion temperature, gas and liquid permeability, solvent resistance, and so on. But These improved properties are realized only when silicate particles are well dispersed in polymer matrix. Therefore it is very important to make well dispersed system, intercalated or exfoliated system, and to verify the internal structure of nanocomposite.

Many studies characterized the internal structure of nanocomposite in terms of X-ray diffraction (XRD), transmission electron microscope (TEM). XRD results show the space of intragallery region of silicate layers. But no peak appears when layered silicate is completely exfoliated, and so TEM image is used to verify the exfoliated structure in addition to XRD results. Nevertheless, TEM image do not provide quantitative analysis but only qualitative analysis. In contrast to the data of XRD and TEM, rheological data provide the quantitative analysis for the internal structure of nanocomposite, in particule, the exfoliated structure.

In order to evaluate the structure and quality of nanocomposite rigorously, rheological characterizations are necessary more than XRD and TEM. In this study, rheological behavior of nanocomposite materials in shear and extensional states were investigated in connection with the analysis by XRD and TEM. Rheological characterizations are also necessary to apply nanocomposite to the polymer processing such as extrusion, fiber spinning, film blowing, and so on.

2. Experiments

2.1. Materials

Polyamide 6 from Kolon is selected to matrix resin and organoclay supplied by Southern Clay Products, because it is known that polyamide 6/organoclay nanocomposite reaches the exfoliated structure well.

2.2. Melt Compounding

Melt compounded composites were prepared using a Brabender counter-rotating intermeshing twin screw extruder at a barrel temperature of 240 °C.

2.3. Characterization

Wide angle X-ray diffraction (M18XHF-SRA) and small angle X-ray diffraction (Rigaku Max-3 Cg

X-ray diffractometer) was used to determine the d-spacing of layered silicate. TEM (CM-20, JEM-3000F) image showed the dispersion of layered silicates.

RMS results were used to examine flow behavior of nanocomposite in shear flow field. RME was used to investigate extensional behavior of nanocomposite.

3. Results and Discussion

Wide angle X-ray diffraction peaks were shown in Figure 1. Peak by layered silicate moved to lower angle in nanocomposite peak, which described intercalation of silicate layer into the polymer matrix. Figure 2 showed viscosity behavior of nanocomposite. Nanocomposite represented a strong shear thinning behavior, while neat polymer showed almost Newtonian behavior. It is an obvious evidence that nanocomposite has a viscoelastic properties.

In addition to TEM analysis, RME test will examine the precise structure and rheological properties of nanocomposite, in particular, at the state of extensional flow.

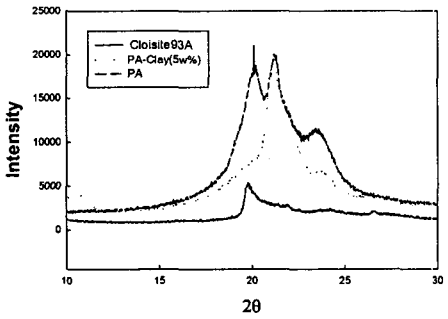

Figure 1. Wide angle X-ray diffraction of polyamide 6, organoclay(Cloisite 93A), and polyamide 6/organoclay(5 wt%) nanocomposite.

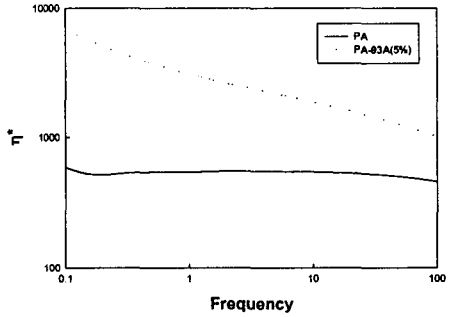

Figure 2. Complex viscosity of polyamide 6 and polyamide 6/organoclay nanocomposite.

4. Conclusions

Polyamide 6/organoclay nanocomposites were produced through melt compounding by twin screw extruder and performed rheological characterization by using RMS and RME as well as structural characterization by XRD and TEM. There were close correlation between the internal structure and rheological properties of nanocomposites, which can be very useful measure of nanocomposite studies.

5. References

T. J. Pinnavaia and G. W. Beall, "Polymer-clay Nanocomposites", pp. 111-126, John Wiley & Sons, 1997.

J. W. Cho, D. R. Paul, "Nylon 6 nanocomposites by melt compounding", Polymer, 42, pp. 1083-1094(2001).

Ramanan Krishnamoori, Koray Yurekli, "Rheology of polymer layered silicate nanocomposites", Current Opinion in Colloid & Interface Science, 6, pp. 464-470(2001).

T. D. Foenes, P. J. Yoon, H. Keskkula, D. R. Paul, "Nylon 6 nanocomposites: the effect of matrix molecular weight", Polymer, 42, pp. 9929-9940(2001).

Peter C. LeBaron, Zhen Wang, Thomas J. Pinnavaia, "Polymer-layered silicate nanocomposites: an overview", Applied Clay Science, 15, pp. 11-29(1999).

Thomas Schweizer, "The uniaxial elongational rheometer RME - six years of experience", Rheologica Acta, 39, pp. 428-443(2000).