한국섬유공학회 학술발표회 논문집, 제 36 권 제 2 호 024-3-A10

용융혼합법을 이용한 생붕괴성 나노복합재의 제조 및 분석

이수경, 윤재륜
서울대학교 재료공학부

Preparation and Characterization of Biodestructive Nanocomposites by Melt Intercalation Method

Su-kyung Lee and Jae Ryoun Youn
School of Materials Science and Engineering, Seoul National University, Seoul, Korea

1. Introduction

Nanocomposites are composite materials consisting of polymer matrix and layered silicate that are interacted in nanometer scale. Layered silicate based polymer nanocomposites have attracted considerable attention because of their excellent properties. Nanocomposites usually exhibit improved performance properties compared with conventional composites due to their unique phase morphology and improved interfacial properties. They exhibit high tensile strength and modulus, good heat resistance, solvent resistance, flame retardance and decrease gas and liquid permeability. But these improved properties are obtained when silicate layers are well dispersed in polymer matrix. Therefore it is important to make well dispersed system, ideally exfoliated system.

Recently a biodegradable resin and organically modified montmorillonite nanocomposites are deeply investigated due to the environmental concerns. The environmental impact of plastic wastes is glowing more global problems, and alternative disposal methods are limited. Incineration of the plastic wastes always produces a large amount of carbon dioxide and toxic gases and creates global warming which contribute to environmental pollution.

In theses reasons, many researchers are investigating biodegradable nanocomposites which are environmentally friendly and have improved properties than the unmodified resin. There are many studies which deal with PLA(polylactide) based nanocomposites. But, it is still required to verify other properties such as rheological properties.

In this study, nanocomposites are prepared through melt intercalation method and characterized by SAXS and TEM. And rheological properties of nanocomposite materials are considered in shear and extensional modes.

2. Experimental

2.1. Materials

Biodestructive resin under the trade name of GREENPOL from SK Corporation was selected to matrix resin. It is a copolymer system which consists of polyethylene, aliphatic polyester and starch. The two different types of organoclays, Cloisite 30B and Cloisite 15A, used in this study were supplied by Southern Clay Products. They were synthesized by replacing Na^+ ions in

different layered silicates with methyl tallow bis-2-hydroxyethyl quatenrnary ammonium for Cloisite 30B and dimethyl dihydrogenatedtallow quaternary ammonium for Cloisite 15A.

2.2. Nanocomposite preparation

Nanocomposites were prepared by melt intercalation method. Organoclay and resin were first dry-mixed by shaking them in a bottle. The mixture was then dried under vacuum at 80℃ for more than 48 hours. Nanocomposites were melt compounded using Brabender PLASTICORDER PLE-651 counter rotating intermeshing twin screw extruder at a barrel temperature of 160℃ and a screw speed of 50rpm with four different organoclay contents of 1, 3, 5 and 7 wt%.

2.3. Characterization

The internal structure of nanocomposites was investigated by using small angle X-ray scattering, Rigaku Max-3 Cg X-ray diffractometer operated at 40 kV, 35 mA with Cu Kα radiation (λ = 0.154184 nm). TEM, Jeol JEM-2000EX II was used for the exact characterization of the nanocomposite morphology. TEM specimens was microtomed to an ultra thin section with a thickness of about 80 nm and coated with carbon for 7 min to prevent them from degradation caused by irradiation of electrons. RMS results were used to examine flow behavior of nanocomposites in shear mode and RME was used to investigate extensional behavior of nanocomposites.

3. Results and Discussion

Resin selected in this study has not been investigated for nanocomposite matrix yet, so we have to find out which kind of organoclay has affinity with polymer matrix. Nanocomposites comprised of different organoclay are prepared and analysed with SAXS. From the Figure 1, nanocomposite that was synthesized with Cloisite 30B are a well dispersed system which has no characteristic peak.

Figure 2 shows storage modulus of unmodified resin and nanocomposites through oscillatory shear test. As the clay content increases, storage modulus of nanocomposites increases and dependency on clay loading decreases as the clay content increases. It is well known as a solid-like transition. Figure 3 shows complex viscosity of unmodified polymer and nanocomposites. There is an Newtonian plateau in pure polymer. As the clay content increases, nanocomposite shows a shear thinning behavior.

We also investigated extensional flow behavior by using RME. Figure 4 shows extensional viscosity of unmodified rein and Figure 5 shows extensional viscosity of nanocomposites. Nanocomposites show much lesser strain hardening property because the patially exfoliated and intercalated structures are coexisted. In well dispersed nanocomposite system, they shows still strong strain hardening behavior.

4. Conclusions

Biodestructive polymer/organoclay nanocomposites were prepared through melt intercalation method by using twin screw extruder and characterized internal structure by using SAXS and TEM. In addition, rheological properties of nanocomposite were investigated by using RMS and RME. In polymer-clay nanocomposite system, there are solid-like transition of storage modulus and

as the clay content increased Newtonian plateau disappeared and shear thinning behavior could be noticed. And from the results of extensional flow, nanocomposite shows weaker strain hardening behavior compared to nanocomposites owing to weak interactions between polymer chains and clay platelets.

5. References

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

Sinha Ray S, Yamada K, Okamoto M, Fujimoto Y, Ogami A, Ueda K, Polymer 2003;44:6633

Sinha Ray S, Yamada K, Okamoto M, Ueda K, Macromol. Mater. Eng. 2003;288:203

Lee SR, Park HM, Lim H, Kang T, Li X, Cho WJ, Ha CS, Polymer 2002;43:2495

Okada K, Mitsunaga T, Nagase Y, Korea-Australia Rheology Journal 2003;15:43

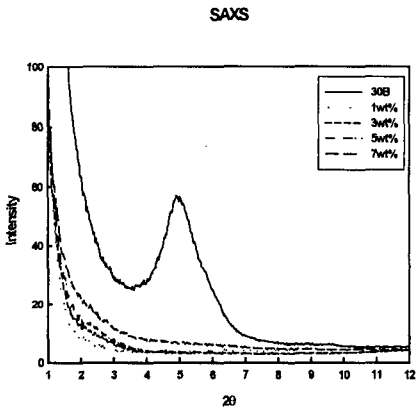

Figure 1. Small angle X-ray scattering of organoclay and nanocomposites

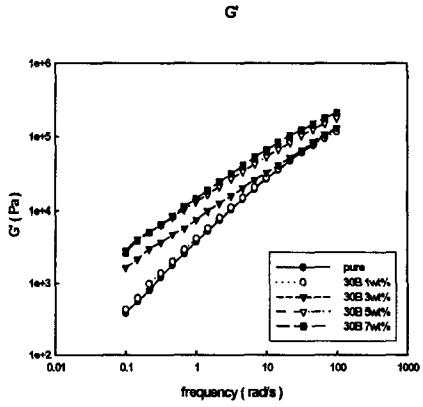

Figure 2. Storage modulus of unmodified polymer and nanocomposites

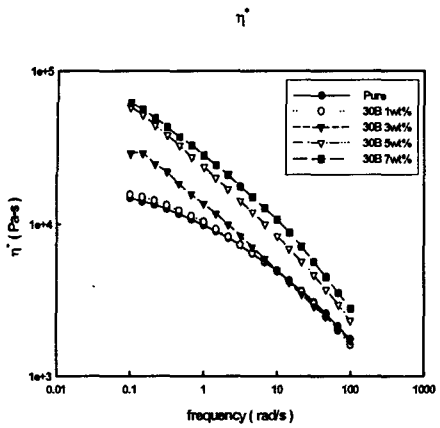

Figure 3. Complex viscosity of unmodified polymer and nanocomposites

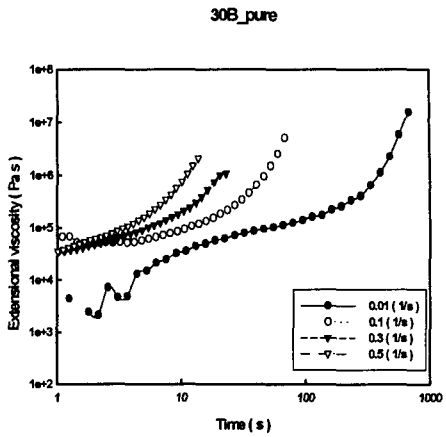

Figure 4. Extensional viscosity of unmodified polymer with different extensional rate

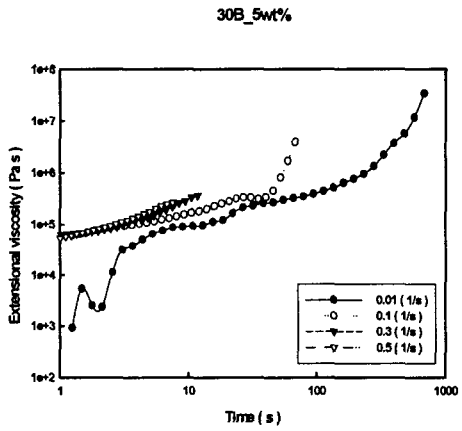

Figure 5. extensional viscosity of nanocomposite with different extensional rate