

Melt rheology of maleic anhydride polypropylene blended with EMAA-ionomer

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Abstract

The purpose of this study is to clarify the rheological properties of maleic anhydride polypropylene (MAPP) / ionomer blends.

We measured dynamic viscoelasticity and uniaxial elongational viscosity of the blends and researched the influence of ionomer blends on strain-hardening of MAPP.

1 Introduction

Ionomer is polymer that has a few mole percent of ionic groups into polymer chains. The ionomer has excellent toughness, transparency and wear resistance by aggregates of ionic groups¹⁾. The properties of ionomer depends on amount of ionic groups (neutralization degree) and the kind of metallic ion. EMAA-Na ionomer is copolymer of ethylene-methacrylic acid in which a part of methacrylic acid is neutralized by metallic ion Na⁺. Nishioka et al. reported that a strain-hardening of copolymer of styrene and methacrylic acid (StMAA) became larger by blending with EMAA-Na ionomer²⁾. They reported that strain-hardening of StMAA became larger by the interaction of Na⁺ of EMAA-Na ionomer with COOH of StMAA. We considered that this phenomenon can be applied to control of strain-hardening of polymer with COOH group. In this study, we intended to control the strain-hardening of maleic anhydride polypropylene (MAPP) by blending with EMAA-Na. MAPP just shows weak strain-hardening. We considered that the grafted maleic anhydride group changes to maleic acid easily. It is expected that strain-hardening of MAPP is influenced by the interaction between COOH in MAPP and Na⁺ of EMAA-Na. Our purpose of this study is to examine the effect of ionomer blending on the strain-hardening of maleic anhydride polypropylene (MAPP).

2 Experimental

Material

MAPP has grafted anhydride species onto the polypropylene chain. Neutralization degrees of EMAA-Na ionomer were 20% and 54%, these were designated as E20Na and E54Na. MAPP was provided by Mitsui Chemicals.

EMAA-Na was provided by DU PONT-MITSUI POLYCHEMICALS CO.,LTD. These samples were mixed by co-rotating twin screw extruder (KZW-30, L/D=45). The rotating speed was 100rpm and barrel temperature was 200°C. The details of blends are shown in table1.

Table 1 : Sample composition and code

Code	MAPP	E20Na	E54Na
	(wt%)		
MAPP	100	0	0
MAPP/E20Na(90/10)	90	10	0
MAPP/E54Na(90/10)	90	0	10

Experiments

Uniaxial elongational viscosity measurements and dynamic viscoelasticity measurements were performed with an ARES (TA Instruments) under nitrogen atmosphere.

4 Results and discussion

Figure1(a) showed the uniaxial elongational viscosity of MAPP. The solid line indicates linear elongational viscosity ($3\eta_s(t)$) that is calculated from the result of dynamic viscoelasticity

measurement. The data showed weak strain-hardening at the higher strain rates regions ($\dot{\epsilon} \geq 0.5(1/s)$). On the other hand, at the lower strain rates regions ($\dot{\epsilon} < 0.5(1/s)$), the data did not show strain-hardening. Figure 1(b) and (c) showed the uniaxial elongational viscosity of MAPP/E20Na(90/10) and MAPP/E54Na(90/10), respectively. Both of the data showed strain-hardening at not only higher strain rates regions, but also lower strain rates regions. Furthermore, linear elongational viscosity of MAPP/E20Na(90/10) and MAPP/E54Na(90/10) were larger than that of MAPP. Figure 2 showed the storage modulus G' obtained from dynamic viscoelasticity measurements. These data showed same behaviour at the higher frequencies regions except for MAPP. At lower frequencies regions, the slope of G' became smaller and G' increased by loading EMAA-Na ionomer. Though this figure does not show the loss modulus G'' , in particular, the value of G' of MAPP/E54Na(90/10) was nearly equal to G'' . Such a behaviour resembles the data of dynamic viscoelasticity of physical gels.

We considered that MAPP/E54Na(90/10) acted like the gels by the interaction between COOH in MAPP and Na^+ of EMAA-Na. Accordingly, linear elongational viscosity of MAPP/E54Na(90/10) was the largest in figure 1. However, the strain-hardening of MAPP/E20Na(90/10) was larger than MAPP/E54Na(90/10). Both blends are inhomogeneous system with domains of ethylene ionomer. It has been reported that rigid particles reduce the intensity of strain-hardening. We considered that deformation of dispersed particles of E20Na was larger than E54Na in the matrix of MAPP because viscosity of E20Na was lower than E54Na. As a result, the strain-hardening of MAPP/E20Na(90/10) was larger than MAPP/E54Na(90/10).

5 Conclusion

The strain-hardening and linear elongational viscosity of MAPP become larger by blending with EMAA-Na. The strain-hardening of MAPP/E20Na(90/10) was larger than MAPP/E54Na(90/10). The linear elongational viscosity of MAPP/E54Na(90/10) was larger than MAPP/E20Na(90/10).

References

- 1) Vanhoorne P and Register RA, *Low-Shear Melt Rheology of Partially-Neutralized Ethylene-Methacrylic Acid Ionomers*, *Macromolecules*, **29(2)**, PP.598-604(1996)
- 2) Nishioka A, Nishio M, Sugimoto M, Takahashi T, Koda T, Ikeda S and Koyama K, *Uniaxial Elongational Viscosities of Ethylene Ionomer / Styrene-co-Methacrylic Acid Blends*, *J. Soc. Rheol. Jpn.*, **32(1)**, PP.49~53(2004)

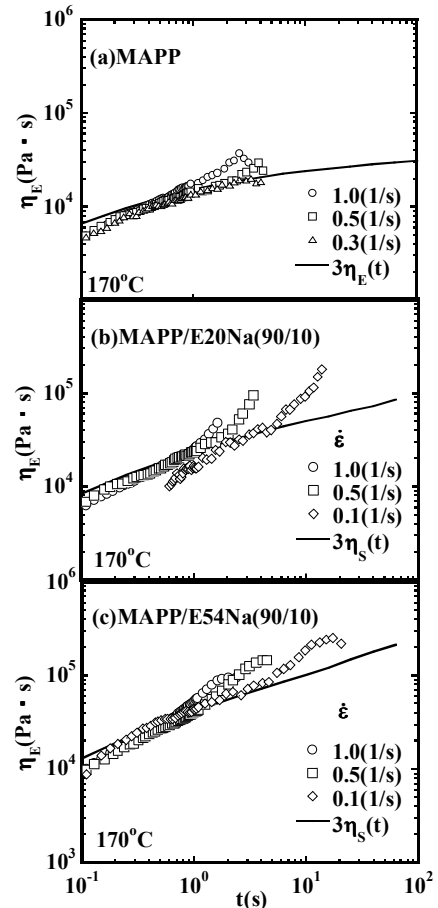


Figure 1: Uniaxial elongational viscosity at 170°C for (a) MAPP, (b) MAPP/E20Na(90/10), (c) MAPP/E54Na(90/10)

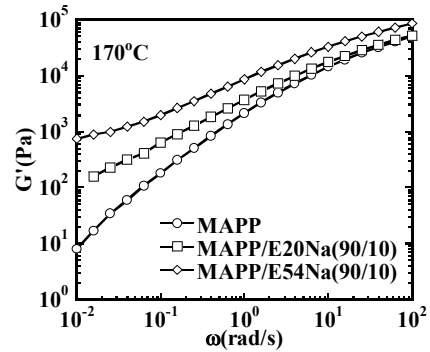


Figure 2: G' curves plotted against angular frequencies at 170°C for MAPP, MAPP/E20Na(90/10), MAPP/E54Na(90/10)