반응동반 TPE/Nylon 6 블렌드의 유변학적, 열적, 기계적 특성

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Rheological, Thermal and Mechanical Properties of in-situ Reactive TPE/Nylon 6 Blends

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Introduction

It is very difficult to obtain good dispersion in polymer blends when the components are essentially mutually insoluble. This is especially true for the combination of a non-polar polymer with a polar polymer, such as thermoplastic elastomer (TPE) with nylon 6 (hereafter called nylon) [1].

TPE has many of elastomeric properties and is processible as thermoplastic. From environment consideration, TPE is recyclable and has become an important position in automotive bumper, weatherstrip, seals, industrial gasket and so on. On the other hand, nylon is an engineering thermoplastic with high strength, wear and heat resistance, ease of fabrication and processing. It is however relatively expensive and has poor impact strength and dimensional stability as well as poor barrier properties to moisture [2-4].

For PP/nylon blends, Ide and Hasegawa [5] added maleic anhydride grafted PP(MAH-g-PP) to the binary blend and obtained almost homogeneous morphology. Similar compatibilization by adding a small amount o MAH-g-PP was also reported for PE/nylon blends by Chen et al [6].

In this study, we consider the rheological, thermal and mechanical properties of TPE/MAH-g-PP/nylon blends under the range of the various compositions.

EXPERIMENTAL

Materials and Preparation

L2K55NU type (TPE, Hwaseung R&A), Ultramid B3 type (BASF, M_n=18,000) and an MAH-g-PP (Uniroyal Chemical, 3150, 0.5wt% maleic anhydride) were used after drying in vaccum at 70℃ for 48hr.

Blends were prepared in single screw extruder (Haake Rheometer) at 100rpm, and temperature profile 225, 235, 230, 230℃, respectively. The extrudate was obtained in the form of sheet (thickness=0.7㎜). Prior to testing, samples were dried in vacuum overnight at 80℃ to avoid the plasticizing and hydrolyzing effects of humidity on nylon.

Formulations used in this experiment were given in Table 1.

Characterizations

Rheological characterizations were made from a Rheometrics Dynamic Anaylzer (RDA Ⅱ) in a plate and plate type geometry with diameter of 2.5cm. Measurements were carried out isothermally at 240℃. Frequency sweep was done at 15% strain level. And we measured the frequency range of 0.1~100 rad/s.

Thermal properties of the samples were measured using a differential scanning calorimetry (DSC 3100S) with typically 5 ± 0.2mg of molded film. The sample was heated up from room temperature to 300℃ directly and heating rate was programmed at 10℃/min to measure T_m's change of PP and nylon.

Thermodynamic moduli of the blends were measured using the Dynamic Mechanical Thermal Analyzer (DMTA 3E), in a temperature range of -100~250℃ at a heating rates of 4℃/min.

Mechanical properties were measured with Universal Test Machine (Tinius Olsen 1000).

Results and Discusion

Table 2 shows the T_m of PP and T_m of nylon as a function of the blend composition. Obviously, T_m of PP as well as nylon decreases in blends. However the extent of decrease is insignificant with blend composition. It is also noted that the ΔT_m (T_m of nylon-T_m of PP) decreases with the increased miscibility between PP and nylon.

Figure 1 shows the complex viscosities of TPE/MAH-g-PP/Nylon ternary blends as a function of oscillating frequency. It is seen that nylon and MAH-g-PP show Newtonian plateau at low frequencies, with a value order of 10^3(Pa · s). On the contrary, the viscosity functions of blends as well as TPE are almost straight line, typical of elastomeric behavior. Among blends, viscosity decreases with increasing nylon and MAH-g-PP although their viscosities at low frequency, say $\omega = 10^{-1}$rad/s, is order of 10^5(Pa · s), which is two order of magnitude higher than that of nylon and MAH-g-PP.

The dynamic behavior of the ternary blends as well as each component are given in Figure 2. It is seen that nylon shows its T_g at about 50℃, and T_m at about 215℃. With ther addition and increasing amount of nylon 6 and MAH-g-PP, T_g of EPDM decreases from -46.82℃ to -54.62℃. This is most likely due to the increased phase separation of EPDM and PP, with increasing amount of MAH-g-PP.

Such behavior has also been observed polybutadiene/SAN blends, where the T_g of polybutadiene decreased with increasing amount of free SAN.

Figure 3 shows the tensile behavior of TPE/MAH-g-PP/Nylon and TPE/MAH-g-PP blends. In both of the blends, elongation at break decreases and tensile strength increases with increasing amount of thermoplastics. However, effect is more pronounced with ternary blends.

Conclusion

T_m of PP as well as nylon decreased in blends independent of the blend composition, due probably to the dilution effect of the other component. The dilution effect should be augmented by the compatibilizing effect of

MAH-g-PP.

T_g of EPDM decreased with the addition and increasing amount of MAH-g-PP and nylon in ternary blends, due presumably to the increased phase separation of EPDM and PP.

References

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Table 1. The composition of various TPE/MAH-g-PP/Nylon

	TPE(wt%)	MAH-g-PP(wt%)	Nylon(wt%)
1	60	20	20
2	70	15	15
3	80	10	10
4	86	7	7
5	90	5	5
6	94	3	3
7	100		
8			100
9		100	

Table 2. DSC data for various composition

	T_m of PP(℃)	T_m of Nylon(℃)	$\Delta T_m{}^a$(℃)
1	156.0	220.0	64.0
2	155.1	220.1	65.0
3	153.9	219.8	65.9
4	154.5	220.0	65.5
5	153.4	219.9	66.5
6	153.1	219.8	66.7
7	154.9		
8		223.0	
9	163.8^b		

a : the degree of T_m of Nylon - T_m of PP(℃)
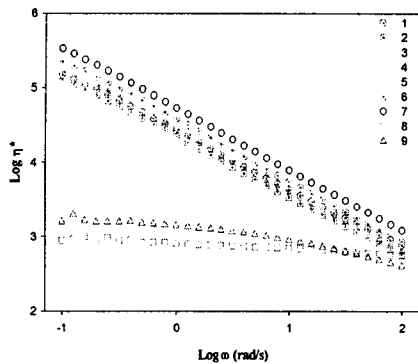b : T_m of MAH-g-PP(℃)

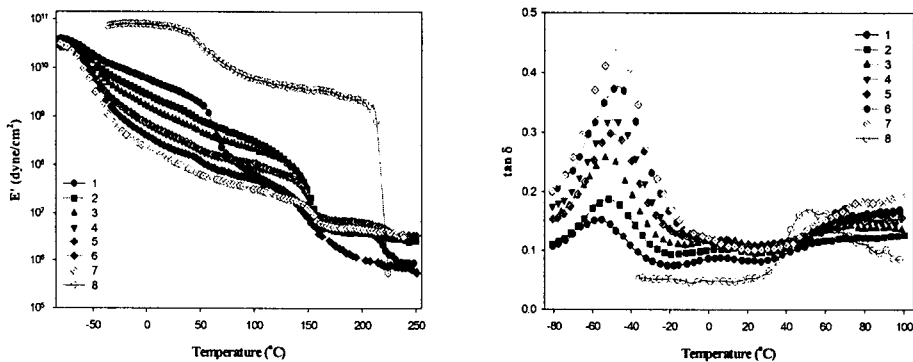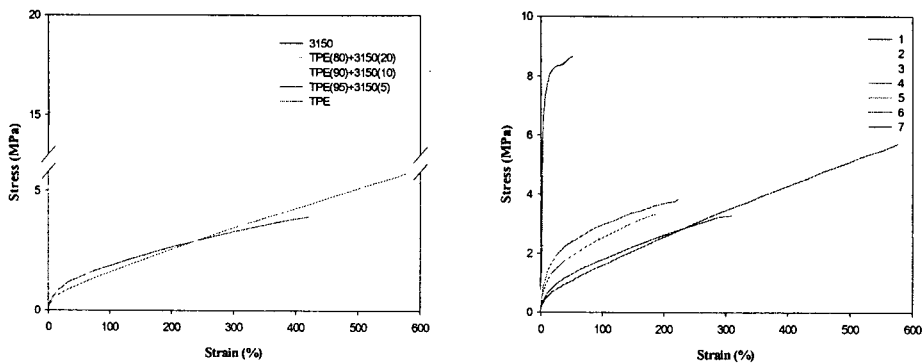Figure 1. RDA data for various composition.

Figure 2. DMTA data for various composition.

Figure 3. UTM data for various composition.