NOTE

Morphology and Thermal Behavior of PA1010/LLDPE Blends using PE-g-AA as a Compatibilizer

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INTRODUCTION

The properties of blends of immiscible polymers are often closely related to the phase morphology. The morphology usually depends on parameters such as composition, viscosity ratio, and interfacial tension of the component phase as well as processing conditions during mixing.¹⁻⁴ In recent years, there has been much interest in the blends of polyamides and polyolefins. When properly compatibilized, polyamide and polyolefin blends can potentially offer a wide range of desirable characteristics such as good chemical resistance, low water sorption, and reduced cost, and the mechanical properties depend strongly on the ratio of polyamide to polyolefins.⁵

Blends of PA6 and PA66 with polyolefins have been studied for many years.⁶ However, very little work on the application and modification of PA1010 has been investigated.⁷ Only in recent years PA1010 blends with PA6⁸ and PP⁹ were reported. Reported here are observation on the morphology of PA1010/LLDPE blends.

EXPERIMENTAL

Materials and Specimen Preparation

Granular polyamide1010 (PA1010) is a commercial product with η_r 2.1–2.3, obtained from the Shanghai

Celluloid Factory, and linear low-density polyethylene (LLDPE) was obtained from the Qilu Petrochemical Corporation of China. Its trade name is DFDA-7042, and the acrylic acid-grafted polyethylene (PE-g-AA) was obtained commercially in Guangzhou. They were used as received after drying.

Blending was performed in the melt state at 230° C with a XSS-300 Rheomix (Shanghai Light Machine Factory), the volume of the mixing head was 60 cm³, and mixing was continued for 8 min at 33 rpm.

Scanning Electron Microscopy

The morphology of the blends were obtained by scanning electron microscopy (SEM) using an Hitachi S-520 electron microscopy operated at 25 kV. Melt-pressed specimens were freeze fractured under liquid nitrogen, and sputter coated with gold before viewing.

Differential Scanning Calorimetry

DSC measurements were performed with a Perkin– Elmer model DSC-7 equipped with an intracooler. During the thermal treatments and DSC Scanning, a dry nitrogen purge was provided throughout to prevent oxidation of the specimens.

RESULTS AND DISCUSSION

Morphology

Morphology of the blends were examined by SEM. In uncompatibilized blends, different components of the

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Figure 1 SEM micrographs of PA1010/LLDPE blend: (a) 95/5, (b) 70/30.

blends have similar morphologies: a dispersed phase of one component in a matrix of the remaining component, the dispersed phase exists as large spherical particles or an ellipsoid particle, the two phase are well separated, and the adhesion is poor, as shown in Figure 1. Many voids suggest that the dispersed particles are pulled out during the cryogenic fracture because of the poor adhesion between the two phases.

In contrast, SEM photomicrographs of the compatibilized blends reveal some quite different type of morphology, particles are well distributed, and are much smaller than those in uncompatibilized blends as shown in Figure 2. With the increasing of the LLDPE component in the blends, the size of particles gets large to some extent. Furthermore, in compatibilized blends, dispersed particles show three type of main morphology, as shown in Figure 3: (1) lotus root fractured the surface-like phase as a core, around which it was tightly linked with the matrix-like spoke. (2) A particle as the core, surrounded tightly with the matrix-like spoke. (3) A wheel-like morphology, in which the core is a ring. These morphologies show good adhesion in the interface. The result should be attributed to the chemical interaction taking place between acrylic acid groups of PE-g-AA and --NH2 or --NH-- groups of PA1010 during the melt blending, and the PE-g-PA1010 copolymer formed by the reactions acts as a

compatibilizer, thus improving the affinity between PA1010 and PE. $\,$

Thermal Behavior

Samples of blends with different compositions were held at 250°C for 3 min to destroy all crystalline nuclei before cooling at 10°C/min to 50°C, held at that temperature for 2 min, then scanned to 250°C at a heating rate of 10°C/min. Figure 4 shows the melting and crystallization behavior of the PA1010/LLDPE/PE-g-AA blends. In Figure 4(a), the LLDPE component in the blends give one melting peak, and the melting temperature (T_m) shifted to a little higher temperature than in bulk. Similarly, in Figure 4(b), the crystallization temperature (T_c) of the LLDPE component also shifted a little to a higher temperature than in bulk. By contrast, in Figure 4(a), the PA1010 component gives two melting endotherms. No noticeable variation in melting temperature was found compared with the PA1010 bulk, although the relative peak heights of the lower melting peak decreased with the increasing of the LLDPE component. The crystallization temperature of the PA1010 component in the blends is much higher than those of pure PA1010, and the crystallizing peak



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Figure 2 SEM micrographs of PA1010/LLDPE/PE-g-AA blends: (a) 90/10/10, (b) 70/30/10, (c) 60/40/10.



Figure 3 SEM micrographs of PA1010/LLDPE/PE-g-AA blends: (a) 90/10/10, (b) 80/20/10, (c) 70/30/10, (d) 60/40/10, (e) 70/30/10.



(e) **Figure 3** (Continued from the previous page)



Figure 4 DSC curves of PA1010/LLDPE/PE-g-AA blends: (a) melting, (b) crystallization.



Figure 4. (Continued from the previous page)

Table I	DSC Data	of PA1010/LLDPE/PE-g-AA	Blends
in Heati	ng Process	(°C)	

PA6/LLDPE/ PE-g-AA	PA1010			LLDPE	
	T_o	Т	m	T_o	T_m
100 /0/0	193.9	191.6	201.0	/	/
90 /10/0	194.1	191.9	202.6	118.4	122.7
70 /30/0	194.7	192.4	202.6	118.0	122.8
0 /0/100	/	/	/	120.1	128.4
90 /10/10	194.8	192.6	201.7	122.4	129.6
80 /20/10	194.1	192.6	201.5	121.3	128.1
70 /30/10	193.6	191.3	201.2	121.1	128.1
60 /40/10	193.1	191.3	201.7	121.5	129.8

 $T_o-\!\!\!$ onset temperature. $T_m-\!\!\!$ temperature of melting peak.

	PA1010		LLDPE	
PA6/LLDPE/ PE-g-AA	T_o	T_{c}	T_o	T_{c}
100 /0/0	170.9	165.3	/	/
90 /10/0	100.6	177.7	113.3	108.2
70 /30/0	179.6	177.2	111.9	108.1
0 /0/100	/	/	114.2	111.8
90 /10/10	179.0	176.3	116.1	111.0
80 /20/10	179.3	176.4	115.7	110.1
70 /30/10	179.6	177.1	115.0	112.4
60 /40/10	179.6	177.1	115.8	113.1

Table IIDSC Data of PA6/LLDPE/TR Blendsin Cooling Process (°C)

 T_o —onset temperature.

 T_c —peak temperature of crystallization.

of PA1010 in the blends gets narrow. It can be conclude that in the blends, the degree of perfection of PA1010 crystals increased.

In uncompatibilized blends, similar DSC results were obtained, but the melting temperature of LLDPE

shifted a little to a lower temperature. The DSC data are summarized in Tables I and II.

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