

NOTE

Morphologies and Tensile Properties of PA6/HIPS/HIPS-*g*-MA

GUANGXIN CHEN, WENFEI DONG, JINGJIANG LIU

State Key Laboratory of Polymer Physics and Chemistry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun, 130022, Peoples Republic of China

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EXPERIMENTAL

Materials

HIPS used in this study was a commercial product (492-J) manufactured by Yanshan Petrochemical Co., Beijing, China, and its melting flow index is 3.1 g/10 min. The content of polybutadiene is 7% in HIPS. PA6 with $M_n = 19,600$ was supplied by the 18th plastic plant, Shanghai, China. The HIPS-*g*-MA was prepared by melt mixing in our laboratory, and the content of MA in HIPS-*g*-MA used in this work was 4.7 wt %.

Tensile Property Measurement

Testing specimens for mechanical properties were prepared by using a JSWF17SA injector with a barrel temperature of 225–235°C. Measurements of tensile properties of specimens were carried out on an Instron 1121 machine at room temperature with crosshead speed of 5 mm/min. Five specimens of each blend were tested, and average values were taken as experimental data.

RESULTS AND DISCUSSION

Morphology

The TEM photomicrograph is the most convenient approach to differentiate the morphologies between a

compatibilized blend and an uncompatibilized counterpart.¹ The morphologies of PA6/HIPS blends compatibilized with HIPS-*g*-MA are examined by TEM. Figure 1 shows photomicrographs of the series of blends containing 75% PA6 with varying amounts of HIPS-*g*-MA. For the blends without any HIPS-*g*-MA compatibilizer, rubber particles in the cellular structure of the HIPS exist in certain regions in which the biggest diameter is about 10 μm . The rubber particles in the cellular structure of the HIPS are entirely absent in the other regions that must consist primarily of PA6 [Fig. 1(a)]. These results show that the cellular structure features and the morphological characteristic in HIPS are not broken, and they are kept in the PA6/HIPS blends totally. The worse miscibility between PA6 and HIPS can be conducted from these observations. For the compatibilized blends, the morphologies shown in Figure 1(b) and (c) reveal that the sharp boundaries and clear gaps between the dispersed phase and the matrix have disappeared. Due to the interfacial reaction between PA6 and HIPS-*g*-MA, the interfacial situation between PA6 and HIPS is absolutely changed.²

Tensile Property

From the morphological observation we realized that the PA6-*g*-HIPS copolymer, which is formed during melt mixing, acts as a compatibilizer of the PA6/HIPS blends. The mechanical properties of binary and ternary blends are summarized in Table I, an increase in the tensile properties is observed when HIPS-*g*-MAs are introduced into blends of PA6/HIPS. The low tensile properties of PA6/HIPS blend can be related essentially to the larger size of the HIPS domains with a poor adhesion to the matrix. These domains act as gross material defects, causing premature rupture of the

Correspondence to: J. Liu.

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specimen soon after the beginning of yield. On the other hand, in PA6/HIPS/HIPS-*g*-MA blends, all particle size reduction and an improvement of interfacial adhesion, caused by the formation of PA6-*g*-HIPS copolymer at the interface between PA6 and HIPS, seem to lead to the improvement of mechanical properties.

Because the tensile yield strength of the HIPS material is lower than that of the PA6 matrix, an indication of the interfacial strength is derived from the extent to which the HIPS particles are deformed when the blend fractures. The better adhesion provided by 9 wt % HIPS-*g*-MA was manifest primarily in the ultimate elongation. The tensile energy and elongation at break of the PA6/HIPS/HIPS-*g*-MA blends are improved more than 10 times with adding HIPS-*g*-MA from 0 to 9 wt %. It was presumed that interfacial strength in the blends was determined primarily by interaction of the compatibilizer with PA, because ad-

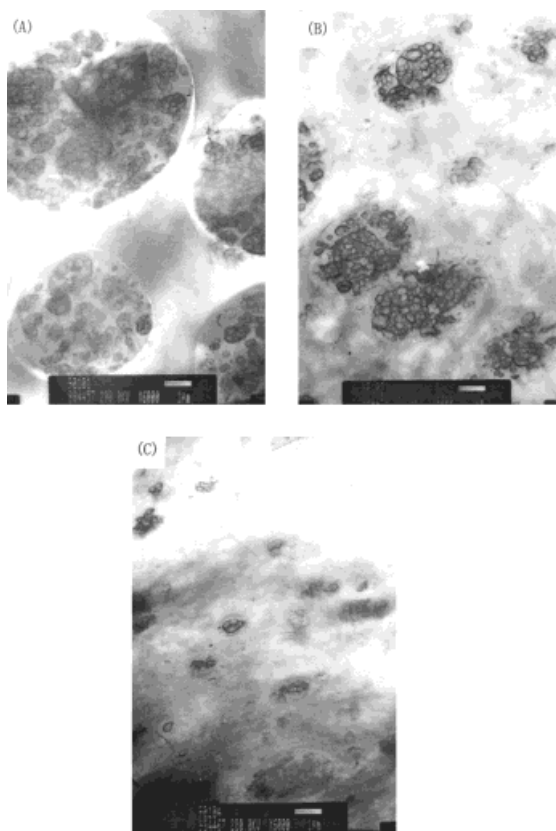


Figure 1 TEM photomicrographs for 75% PA6 blends containing (A) 0%, (B) 3%, (C) 9% HIPS-*g*-MA. The sample was stained with O_3O_4 .

Table I Tensile Properties of Ternary Blends

PA6/HIPS/ HIPS- <i>g</i> -MA	Strength (MPa)	Energy (J)	Elongation (%)	Modulus (MPa)
75/25/0	41	1.3	30	1229
75/22/3	44	2.4	52	1246
75/16/9	62	20	207	1260

hesion to HIPS is provided by chemical linkages. The interaction of HIPS-*g*-MA with PA6 is strong enough to sustain particle–matrix adhesion as the compatibilizer is drawn along with the PA. Interfacial agents generated *in situ* during the process of melt mixing through reaction between chemical functionalities available in the polymer chains have been reported in literature. Both experimental observations and theoretical prediction indicate a reduction in the dispersed phase domain size. In addition, the presence of the compatibilizer at the interface broadens the interfacial region through penetration of the copolymer chains into the adjacent phase.³ These factors mentioned above translated on the macroscale into higher fracture elongation for the blends.

CONCLUSION

The effects of the HIPS-*g*-MA concentration on the tensile properties of blends have been examined. The improved mechanical properties should be attributed to the interaction between HIPS-*g*-MA and PA6. Interfacial adhesion is postulated to increase with increasing the HIPS-*g*-MA content in the blend.

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