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Mechanical Properties and Structure of Novel Polymer Blends and Composites Fabricated by Reactive and High-shear Rotational Processing

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Abstract

Various polymer alloys have been examined to achieve performance beyond that of single polymers. Polyamide 6 (PA6) has extraordinary mechanical properties, impact absorbability, and high heat resistance necessary for exterior and interior automotive applications. Nevertheless, some materials and their combinations can exhibit inferior physical properties. This paper describes a novel polymer blend with PA6, fabricated using high-shear rotational processing. Modulated differential scanning calorimetry (M-DSC), scanning electron microscopy (SEM), and transmission electron microscopy (TEM) elucidated thermal properties and morphologies of PA6 blends. Tensile and Izod tests revealed their mechanical properties. Results show that novel PA6 blends are useful for automotive applications.

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Keywords: Polyamide blends and composites, Polyamide 6 (PA6), High-shear rotational process, Mechanical properties, Morphology

1. Introduction

High performance and multi-functionalization of plastic products with characteristics needed for polymer materials have become widely explored. Polymer alloys with various polymer materials have been studied to assess

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their performance, which transcends that of single polymers. Furthermore, nanoalloys having various characteristics have been proposed. Their reported mechanical properties have been improved drastically [1]. Nevertheless, depending on the selected materials and their combinations, they can be immiscible. Sometimes, their physical properties become worse. Therefore, considerable effort has been taken to develop new materials. Polyamide 6 (PA6) has excellent mechanical properties, impact absorbability, and high heat resistance, which are all required for their use as exterior and interior automotive materials. Accordingly, polymer blends and composites using PA6 have been studied. However, optimizing the balance of rigidity and ductility of PA6 blends persists as a main research topic. In this study, high shear processing technology of a novel fabrication process is used with a screw with a return hole. Moreover, finely dispersed immiscible combinations of PA6 and PP have been done with micrometer and nanometer order. Then the effects on the microstructures and mechanical properties were evaluated.

2. Experimental

2.1. Samples

Polyamide 6 (PA6) was used (T840; Toyobo Co. Ltd.) with polypropylene (PP, J108M; Prime Polymer Co. Ltd.) was used. The compatibilizer was maleic anhydride-modified PP (PP-g-MAH, Yumex 1010; Sanyo Chemical Industries Ltd.). The PA6 and PP blending ratio was 7: 3 (wt). The compatibilizer additive amount was 5 wt%. Table 1 presents the sample characteristics.

Table 1. Characteristics of sample.

Materials		MFR at 230℃ (g/10 min)	T_g (℃)	T_m (℃)	Actual producer
PA6	T840	80	50	220	TOYOBO CO., LTD.
PP	J108M	45	0	165	Prime Polymer Co., Ltd.
PP-g-MAH	Yumex 1010	-	-	148	Sanyo Chemical Industries, Ltd.

2.2. High-shear rotational processing overview and mixing conditions

We used a high-shear rotational processing machine (NHS2-28; Niigata Machine Techno Co., Ltd.) for melt mixing of the PA6/PP blend. A schematic illustration of the high-shear processing machine screw is presented in Fig. 1. The high-shear processing machine is used for this novel fabrication process with mixing by high-speed screw rotation (max. 3000 min^{-1}) and extensional flow [2] passing through the return hole of the screw [3, 4].

We conducted melt mixing at 230°C. The return hole diameter of the screw was 0.5 mm. Screw rotation speeds were 500, 1500, and 3000 min^{-1}. Mixing times were 10 s and 30 s. After high-shear processing, dumbbell specimens were molded using a micro-injection molding machine (ELJECT AU3E-s; Nissei Plastic Industrial Co. Ltd.).

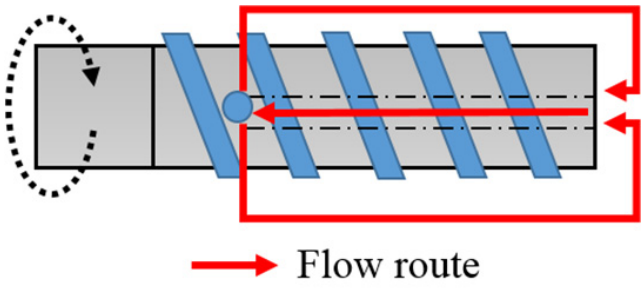

Fig .1 Schematic illustration for High-shear processing machine screw