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The Effect of Carbon Fibre Reinforced on Polyamide1012

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Abstract

A series of composites of carbon fibre-reinforced polyamide1012 (PA1012) were prepared which the carbon fibre content was from 5% to 40%. Their thermo-mechanical properties and fracture morphology were characterized by means of thermogravimetric analysis (TGA), a microcomputer-controlled electronic universal tester, and Scanning Electron Microscopy (SEM), respectively. The results showed that the initial decomposition temperature of the composite was above 400C. With the increase in carbon fibre content, the tensile strength and elastic modulus of the composites were improved. When the carbon fibre content was 15%, it was found that the maximum values of tensile strength and elastic modulus were 87.01 MPa and 438.31 MPa, respectively. The images of SEM showed that the surface modified carbon fibre was superior to original carbon fibre. It was also observed that the surface of modified carbon fibre had some particles that may have contained the ester group, which could have improved the interfacial bonding strength.

Keywords: Carbon Fibre; PA1012; Composite; Thermo-mechanical Properties

1 Introduction

PA1012, which has a high-carbon alkyl group, was used to replace the metal material because of its numerous advantages, such as lower water absorption, stable size, high strength and good toughness. It is widely used in machinery, automobiles, the military, aerospace and other fields [1]. Thus, improving its mechanical properties was the main focus of current research. Zhou et al. [2] used acrylate polymer, grafted by glycidyl methacrylate (ACR-g-GMA), to improve the toughness of PA1012. When the ACR-g-GMA content was 9%, the notch impact strength reached the maximum value which was 3.8 times as high as that of PA1012. But the tensile strength decreased by about 18%. Xu et al. [3] used styrene-maleic anhydride (SMA) to reinforce the copolymer PA1012 and acrylonitrile butadiene styrene (ABS). The blends were prepared by using melt blending method. It was found that when the content of SMA was 5% and ABS content

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was 50%, the PA1012/ABS/SMA blend had the optimal impact strength. With the increase of the SMA content, the crystallization temperature of the blend would increase and then decrease. There are hardly fibre materials which were used to reinforce the PA1012.

Carbon fibre is a new type of material, which has high strength and modulus. It also has other excellent properties, such as like low density, low coefficient of thermal expansion and good heat resistance. Carbon fibre is usually used as reinforced material because of its outstanding performance in aircraft manufacturing, national defence, military industry, automobile, medical equipment, sport equipment and so on [4]. The surface of original carbon fibre is non-polar because of the copious presence of inert graphite crystallite [5, 6]. This structure resulted in bad wetting properties and interfacial bonding properties with the resin. There were three ways to modify the surface of carbon fibre. One was to introduce active functional groups, such as carbonyl, carboxyl and hydroxy, to enhance the wetting properties and bonding capacity [7]. The second was to sculpture some groove on the surface of the carbon fibre to increase the specific surface area for the sake of forming a mechanically interlocked structure with the resin [8]. The third was to remove the weak interface layer on the surface of the fibre. Yang et al. [9] used carbon fibre, modified by a silane coupling agent, to reinforce the epoxy and found that the interlaminar shear strength increased by about 42%, and the wetting properties were also improved. Yu et al. [10] used potassium peroxydisulphate ($K_2S_2O_8$)/silver nitrate ($AgNO_3$) to treat the surface of the carbon fibre. The results showed that the interlaminar shear strength increased by 62.5%, while the surface was not destroyed. This was a pleasing outcome.

The thermoplastic resin reinforced by carbon fibre is one of the main materials of interest to current researchers all over the world [11, 12, 13, 14]. The composite can also be recycled because of the thermoplasticity of the resin. Zhang et al. [15] used carbon fibre to reinforce the PA6T/66 copolymer. The composites were prepared by the melt blending technology using a twin-screw extruder. The results revealed that carbon fibre reinforcements enhance the tensile strength and bending strength.

Fibres used to reinforce materials have been significantly applied in many fields [16, 17, 18]. In our study, we used carbon fibre, whose surface was modified to reinforce PA1012, with a view to obtaining some composite materials (C/PA1012). We wanted to find the influence factors of the thermal and mechanical properties of these reinforced materials.

2 Experimental Section

2.1 Materials

Carbon fibre (T700) modified by polyvinyl acetate (PVAc) was purchased from the Toray Company in Japan. PA1012 was procured from Shandong Guangyin New Material Company. Aluminium foil was obtained from Tianjin Angesi Steel Trade Company.

2.2 Preparation and Characterization

The composite materials of carbon fibre and PA1012 were prepared by a two-step process. First, carbon fibre and PA1012 were mixed in the Haake Rotational Rheometer (RheoDrive 7), which was purchased from ThermoFisher Scientific Co., Ltd., for about 10 min by varying the percentage