A STUDY ON PLASMA TREATED CARBON NANOTUBES-REINFORCED POLYPROPYLENE MATRIX COMPOSITES

Soo-Jin Park*, Min-Kang Seo, Jae-Rock Lee
Advanced Materials Division, Korea Research Institute of Chemical Technology, P.O. Box 107, Yusong, Daejeon 305-600, Korea

psjin@krict.re.kr

Introduction

Carbon nanotubes (CNTs) exhibit exceptional Young's modulus and tensile strength as high as 1 TPa and 200 GPa, respectively, in addition to high thermal and electrical conductivities. Hence the natural choice of CNTs as reinforcement to develop better and multifunctional polymeric composite materials [1-3]. One challenge in fabrication of multi-walled carbon nanotubes (MWNTs)-reinforced composites is the homogeneous dispersion of the MWNTs in the polymer matrix so that it has uniform properties and can efficiently handle load transfer during structural excitation. The MWNTs, in their manufactured state, cluster together in any suspension due to the strong van der Waals forces at that scale. Many techniques, such as sonification, chemical modification, and surface treatment of the materials, have been attempted to separate and disperse MWNTs in polymer resins to various degrees of success.

In this work, the rf plasma treatment is performed to modify the surface properties of MWNTs and then we investigate the influence of rf plasma treatment on the change of surface and structural characteristics of MWNTs was studied in mechanical interfacial properties of the MWNTs-reinforced polypropylene (PP) composites.

Experimental

Isotactic polypropylene (iPP) (MFI: 2.9 dg/min at 190℃ and 5 kg, and density 0.90 g/cm^3) was supplied from Honam Chem. Co. Nanotubes (MWNTs) used in this work were manufactured by CVD process (CVD MWNTs, supplied from Iljin nanotech Co. of Korea, degree of purity is >95%, length: 10-50 μm, diameter: 10-20 nm). MWNTs were purified by following method before use. The purification was based on a mixture of concentrated nitric and sulphuric acids in a ratio of 1:3, respectively. Toluene was used to extract MWNTs for 30 min, followed by washing them with distilled water on a sintered glass filter until a pH value about 7 of the solution was reached.

Plasma processing for the MWNTs was carried out using a radio frequency atmospheric pressure plasma (APP) apparatus to generate the plasma (ATMOS™-Multi system, Plasmart). The power required to generate the radio frequency (13.56 MHz) was 300 W.

For the composite production, PP was melt-blended with the addition of several nanotube concentrations specified as wt% in the polymer: 1, 2, 3 and 5% using an internal mixer. The temperature of the mixing system was estimated by a thermocouple regulation of 190℃ and the blending time was 10 min. The mixed samples were then compressed under a pressure of about 8 MPa at 210℃ for 10 min using a hot-press.

The room-temperature volume resistivity of the composites was measured using the four-probe technique with parallel aluminum or platinum contacts according to the ASTM D257 using a resistivity test fixture and an electrometer.

Results and Discussion

Figure 1 shows the effect of MWNT content on volume resistivity of MWNTs/PP composites. At very low MWNT content, the resistivity gradually decreases with increasing the nanotube content. However, at 2 wt%, a definite reduction in resistivity is observed. This stepwise change in resistivity is a result of the formation of an interconnected structure of MWNTs and can be regarded as an electrical percolation threshold. This means that at contents between 1 and 2 wt% MWNTs, a very high percentage of electrons is permitted to flow through the specimen due to the creation of an interconnecting conductive pathway [4].

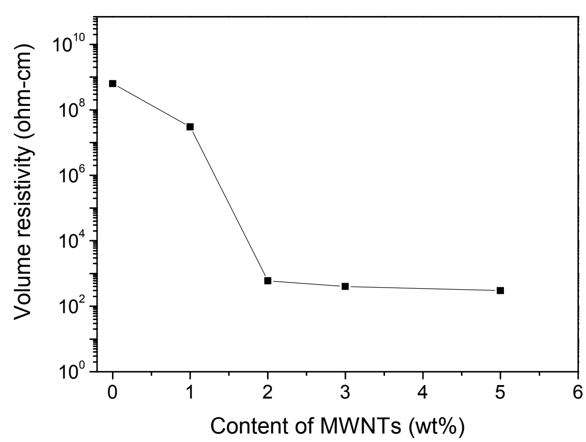

Figure 1. Volume resistivity of MWNTs/PP composites as a function of MWNT content.

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