Analysis of Characteristics of PU/MWNT Film with Electrostatic Dissipation Functions According to Manufacturing Conditions

Seung-Jin Kim[1*], Jun-Hyeong Park

[1]*School of Textiles, Yeungnam University, 214-1, Dae-dong, Gyeongsan-si, Gyeongsanbuk-do, 712-749, Korea*

Abstract: This study analyses the characteristics of PU/MWNT nanocomposite films. For this purpose, several kinds of PU/MWNT nanocomposite films were prepared with four kinds of MWNT, MWNT contents and two kinds of dispersion times. ESD (Electrostatic Dissipation) films composed of polyurethane (PU) block copolymer and selected multi-walled carbon nanotube (MWNT) were also prepared by disperse processing with various MWNT contents and dispersion times. Its mechanical and chemical properties were investigated with respect to electrical conductivity. The tensile properties and chemical properties of PU/MWNT nanocomposite films were measured using UV-visible spectrometer. These properties were also discussed according to the manufacturing conditions of nanocomposite films. Furthermore, PU/MWNT films were made by dispersing them in five kinds of CNT contents and six kinds of dispersion times under the DMF (dimethylformamide) solution. The mechanical properties of the PU/MWNT films were analyzed by Instron and discussed for various dispersion conditions.

Keywords: Nanocomposite, ESD, MWNT, CNT, electrical conductivity.

1. Introduction

Since the industrial revolution of the last century, the use of modern machinery combined with the dry atmosphere produced by central heating has made discharges of this sort common [1]. Therefore, more electrostatic effects actually happened and eventually damages the machine. As a result, static control has become an area of critical concern for electronics manufacturers. Indeed, billions of dollars are lost every year from circuits damaged by static electricity surges during processing and packaging of electronics. The most effective way for eliminating the electrostatic hazard is to get rid of highly electrostatic materials and thus provide an anti-static environment [1].

There are metal fiber, metal flake, carbon fiber and carbon black with fillers to give ESD function until now. Recently, fundamental research on Carbon nanotube (CNT) and their applications have made rapid progress. CNT are long cylinders of covalently bonded carbon atoms with a diameter ranging from a few angstroms to several tens of nanometers across. CNT exhibit excellent mechanical, thermal and electrical properties. Moreover, CNT possess high flexibility, low mass density, and large aspect ratio (typically ca. 300~1000). For these reasons, they have been suggested as ideal materials for the mechanical reinforcement of various polymers while making composites [2,3]. But, cohesion phenomenon by Van der Waals force of CNT appears when distributed in matrix. This is the most difficult problem in CNT dispersion. In most of the cases homogeneous dispersion of nanotubes is hindered by both the synthesis induced 'entangled' and 'aggregated' structures of nanotubes. The aggregation problem presents a major challenge irrespective of the method of composite preparation [4]. To overcome this dispersion problem, melting polymerization, and chemical functionalization incorporated with ultrasonication was carried out [5].

In this paper, the characteristics of the nano-composite film for CVD-grown multi-walled carbon nanotube (MWNT) − Polyurethane are surveyed by analyzing its electrostatic dissipation (ESD) functions. For this purpose the films were made by dispersing MWNT in dimethylformamide (DMF) and combined with polyurethane. The dispersion property of PU/MWNT film was measured with a UV-Vis spectrometer. The mechanical property of film was measured with Instron. Finally, its characteristics according to manufacturing conditions were comparatively analysed and discussed under these conditions.

2. Experimental

2.1 Material

2.1.1 CNT preparation

*Corresponding author's email: sjkim@ynu.ac.kr
JFBI Vol. 3 No.1 2010 doi:10.3993/jfbi06201010

Table 1 shows the characteristics of MWNT used in this study. The four types of MWNT produced in three companies were prepared. They were all made by CVD method.

Table 1 Specification of MWNT

	Property		
	Diameter(㎚)	Length(㎛)	Purity(wt%)
A	5~15	~10	90
B	5~15	~10	＞95
C	10~15	10~20	95
D	10~15	~200	95

2.1.2 Solvent and polyurethane preparation

The DMF was used for mixing with PU as a dispersion solvent. The PU resins used in this study are made by Cytec. Industries Inc. (HI-BON 972DF). PU resins consists of polyurethane 30%, DMF 38.5% (Dimethylformamide) and MEK (Mathyl-ethylketon) 31.5%. The molecular weight ranges from 100,000 to 200,000 and viscosity ranges from 85,000 to 110,000.

2.2 Preparation of dispersion solution

2.2.1 Dispersion conditions for selection of MWNT

For selection of the best conditions for the MWNT dispersion, the experiments related to the dispersion were divided according to the MWNT weight content and dispersion treatment time. Table 2 shows the dispersion conditions for selecting good MWNT. SONICS company's Ultrasonic processor was used for carrying out MWNT dispersion to DMF.

Table 2 Dispersion conditions of MWNT

Content of MWNT(wt%)	Dispersion time(min)
0.5	
1	30
2	120
5	

2.2.2 Dispersion conditions for selected MWNT

Table 3 shows the dispersion conditions of selected MWNT for the best electrostatic dissipation.

Table 3 Dispersion conditions of selected MWNT

Content of MWNT(wt%)	Dispersion time(hr)
0.1	0.5
0.5	1
1	2
2	4
5	8
	24

2.3 Thermal and chemical modification of MWNT

For improving the dispersibility of MWNT, surface modification of MWNT was performed by thermal and acid treatments. Thermal treatment was carried out at 450℃ for 80 minutes in the air furnace. And acid treatment was carried out using nitric acid and sulfuric acid in the ratio 3:1 and impurities were removed.

2.4 Production of PU/MWNT film

Figure 1 shows the manufacturing process of PU/MWNT film. Ultrasonic dispersion of MWNT into DMF was performed. And this dispersion solution and PU were mixed for 1 hour. This mixed solution was casted by Baker Applicator (YBA-4-inch) using a dryer at 150℃ for 120 seconds.

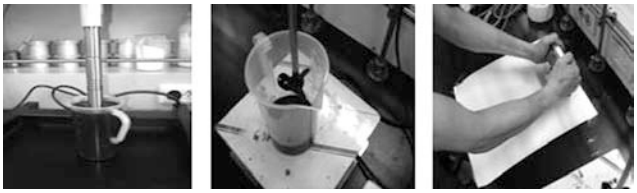

Figure 1 Manufacturing process of PU/MWNT film.

2.5 Measurement of the characteristics of PU/MWNT film

Figure 2 shows the apparatus used for analysis of PU/MWNT film characteristics. The dispersion extent of the PU/MWNT film was measured by the UV-Vis spectrometer, which measures the reflectivity. For the surface profile of the film, SOMETECH's video microscope system (×500) was used. In addition, manufactured PU/MWNT film of mechanical property was measured using Testometric MICRO 350 tensile tester. Electrical properties of the film were measured using KEITHLEY8009 by accessing electrical resistance. The surface profile of PU/MWNT film was