CNT 강화 고분자 복합재 필름의 광발열효과에 관한 고찰
Investigation on the Exothermic Effect of Visible Light Irradiation on Carbon Nanotube-Reinforced Composite Film

***L. D. Tijing [1], 최우림 [1], A. Amarjargal [2], M. T. G. Ruelo [1], 임익태 [1], #김철생 [1,2]**

*L.D. Tijing[1],W.R. Choi[1],A. Amarjargal[2],M.T.G. Ruelo[1],I.T. Im[1],#C.S. Kim[1,2] (chskim@jbnu.ac.kr)

[1]Division of Mechanical Design Engineering, [2]Department of Bionanosystem Engineering, Chonbuk National University, Jeonju, Jeonbuk 561-756, Republic of Korea

Key words : Carbon nanotube, Polyurethane, Composite, Film, Visible light, Solution-evaporation

1. Introduction

Polymer-based composite materials have gained so much attention from researches in academia and industries in recent years. Carbon nanotubes (CNTs) are considered to be one of the most promising reinforcing fillers because of their superior mechanical strength, high electrical and thermal conductivities, and good thermal stability [1-3]. Polyurethane (PU) is among the most widely used polymers because it can easily be processed and has a good resistance to chemicals [2]. In the present study, acid-treatment of MWNT was done to promote dispersion in solution. The objective of this study was to investigate the effect of visible and infrared light on heating MWT/PU composite film, and the effect of MWNT on the surface morphology, characteristics and mechanical properties of the composite film.

2. Materials and Methods

Multi-walled carbon nanotubes (MWNTs, d = 10 nm, 95% purity) were used as filler in the present study. Thermoplastic polyurethane was used as the polymer and dimethylformamide (DMF) as the solvent. MWNT loadings of 0.05, 0.1, 0.5, and 1.0% in 8.3wt% PU were prepared in this study. Pre-dried PU pellets and MWNTs were each dissolved in DMF separately. Both solutions were then mixed and further stirred magnetically for 15-24 h. Bath sonication followed for 2 h and then, the solution was poured on a glass substrate, and lathered smoothly. The solvent was evaporated using a dry oven at 80^{o}C for 24 - 48 h. Figure 1 shows the procedure used in this study. Characterization of MWNTs and films were obtained by FESEM-EDS, TGA and UV-Vis spectroscopy. The mechanical properties were measured by a tensile tester. Exothermic test was done using visible and infrared light sources.

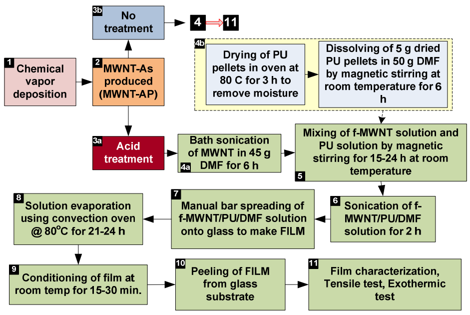

Fig. 1 The present film fabrication procedure

3. Results and Discussion

Figure 2 shows the FESEM images of MWNTs and composite film used in the present study. Many studies show the good effect of acid-treatment (AT) for a better dispersion of CNT in polymer matrix. Good dispersion is an important parameter to enable a good load transfer of CNT to the polymer matrix in order to improve the properties of the composite film [1-3]. Fig. 2c shows only uniform PU surface with small white spots. A closer look (inset of Fig. 2c) confirms the presence of MWNTs embedded in the PU matrix, which are not in bundle. Transparency photos (Fig. 3) clearly show that the film became less transparent when the MWNT loading was increased. The 1.0 wt% loading gave the most opaque film, showing dark color. From Fig. 3, one can also clearly see a uniform dispersion of the MWNT in the film.

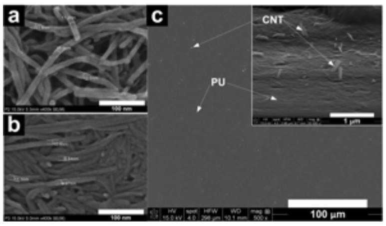

Fig. 2 FESEM images of (a) purified MWNT, (b) acid-treated MWNT, and (c) composite film

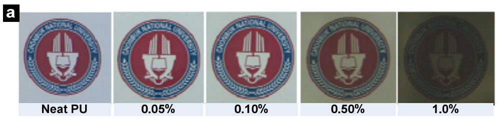

Fig. 3 Transparency photos of composite films.

Figure 4 shows the heating effect of visible and infrared light irradiation on the MWNT/PU composite film. These results are preliminary and are not conclusive yet. When a weak yellow visible light was used as the light source (see Fig. 4a), there was only a maximum of 1°C increase in film temperature. Many studies report on the good absorption of infrared light by CNT thus producing more heating effect, but the heating of visible light has not been reported yet. This heating of MWNT/PU composite film has very good application in phototherapy. The irradiation of infrared (Fig. 4b) on the composite film increased the film temperature by 8-20°C depending on the MWNT loading. This could be attributed to the high thermal conductivity of CNTs as reported in many studies [3].

Figure 5 shows the TGA and tensile test results. The addition of MWNTs on the PU matrix raises the maximum thermal degradation of the composite film (Fig. 5a). The incorporation of MWNTs greatly enhanced the tensile strength of the composite film [3], i.e. an increase of 10-37% from the neat PU tensile strength values (Fig. 5b). There was also an increase of 10-100% in Young's modulus depending on the MWNT loading. Carbon nanotubes are known to be the strongest materials together with graphene. The results also give good strain values, i.e., the composite film's ability to resist mechanical deformation is enhanced without sacrificing its elongation. The best result achieved was at a loading of 0.1 wt%.

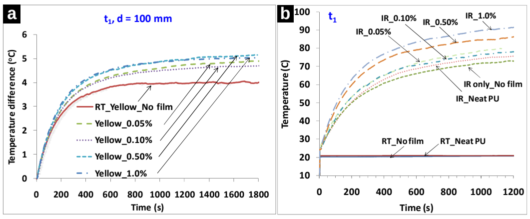

Fig. 4 Exothermic test results for (a) visible, and (b) infrared light irradiation

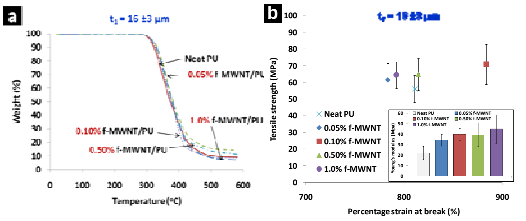

Fig. 5 (a) Thermal degradation and (b) mechanical properties of neat PU and composite film

Acknowledgement

This research was supported by a grant from the Kor. Min. of Educ., Sci. and Tech. through the Regional Core Research Program/ Center for Healthcare Technology Development (Project no. 1345110369).

References

1. Xu, M.; Zhang, T.; Gu, B.; Wu, J.; Chen, Q. Synthesis and properties of novel polyurethane – urea/multiwalled carbon nanotube composites Macromolecules, **39**, 3540-3545, 2006.
2. Xia, H., and Song, M., "Preparation and characterization of polyurethane-carbon nanotube composites," Soft Matter, **1**, 386-394, 2005.
3. Xiong, J., Zheng, Z., Qin, X., Li, M., Li, H., and Wang, X., "The thermal and mechanical properties of a polyurethane/multi-walled carbon nanotube composite," Carbon, **44**, 2701-2707, 2006.