FABRICATION AND PROPERTIES OF POLYMER NANOCOMPOSITES BASED ON CARBON NANOTUBES PREPREGS

G. Trakakis[1*], D. Tasis[1], J. Parthenios[1], C. Galiotis[1, 2] and K. Papagelis[1, 2]

[1]*Institute of Chemical Engineering Sciences - Foundation of Research and Technology Hellas, 26504 Patras, Greece*
[2]*Department of Materials Science, University of Patras, 26504 Patras, Greece*

**trakakis@iceht.forth.gr*

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Abstract

In this work, polymer nanocomposites have been produced by carbon nanotubes prepregs. For this purpose, buckypapers have been fabricated, characterized and optimized for prepreg production and then nanocomposites were produced by autoclave processing. The mechanical properties of the nanocomposites were determined by 3-point bending experiments. The proposed fabrication procedure can be easily extended towards the preparation of CNT-based nanocomposites at an industrial scale.

1 Introduction

Over the last years, huge scientific effort has being carried out to fabricate polymer nanocomposites containing carbon nanotubes [1]. Due to the unique combination of mechanical, electrical and thermal properties of nanotubes [2], they are able to play a significant role as filler materials for nanocomposites, but the nano-scale dimensions of the nanotubes seems to be an inhibiting factor for scientists and industries to successfully produce nanocomposite materials.

In this work, a well-known method at the industry of composites has been optimized and tested, by producing prepregs from carbon nanotubes films, the so-called buckypapers. Buckypapers are thin sheets of randomly entangled CNTs, which are highly porous networks and they can be prepared by vacuum filtration of well-dispersed CNT suspension [3]. Final properties of buckypapers (porosity, structural integrity, thermal and electrical conductivity, etc) can be affected by various factors, such as chemical modification of carbon nanotubes, grafting ratio, solvent and the type of nanotubes [4].

2 Materials and testing methods

Our approach consists of four steps: Firstly, two different chemical modifications of the nanotube surface have been performed and studied (oxidation and epoxidation), to avoid agglomerations of the nanotubes and to achieve a strong bonding with the matrix. Then, after the dispersion of the modified nanotubes into an appropriate solvent, the suspension has been filtrated and dried to form buckypapers (**Figure 1**). The next step is the production of prepregs, by immersing the buckypapers into a liquid epoxy resin-hardener solution and refrigerating in low temperatures (-20 °C). Finally, using an autoclave processing, nanocomposites are produced by these prepregs, as in common composites. The properties of the nanocomposites are strongly affected by the properties of the initial buckypapers [5].

Also, the production of hybrid nanocomposites of nanotubes-graphene oxide was investigated, by the addition of small quantities of GO plates during buckypaper production.

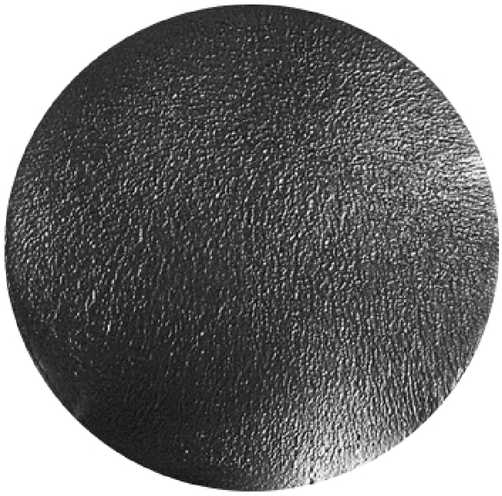

Figure 1. Photo of a neat buckypaper.

3 Results and discussion

The mechanical properties of the resulted composites (**Figure 2**) show a significant improvement (**Figure 3, Table 1**). The flexural stress and Young modulus exhibit an enhancement of 71% and 93%, respectively, for epoxidized nanocomposites compared to the neat epoxy, while the oxidized nanocomposites show an increase at the corresponding values of 47% and 138%. Regarding the thermal properties, the high thermal conductivity of the buckypapers increases the thermal conductivity of the epoxy based nanocomposites from 0.3 $Wm^{-1}K^{-1}$ to 2-6 $Wm^{-1}K^{-1}$. Also, the electrical conductivity of the produced nanocomposites is enhanced many orders of magnitude compared to neat resin.

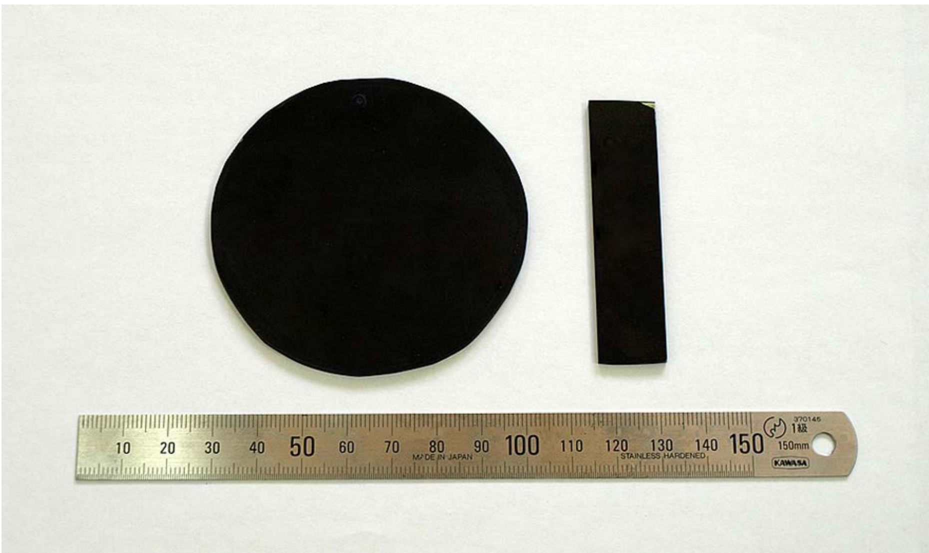

Figure 2. Photo of a nanocomposite sample.

Sample	Modulus of elasticity (GPa)	Flexural Strength, (MPa)	Strain at failure (%)
Resin	3.44±0.12	136±4.6	8.2±0.52
Oxidized CNT/ Resin	8.40±0.32	173±3	3.50±0.3
Epoxidized CNT/ Resin	6.63±0.20	232±5.2	7.6±0.45
Epoxidized CNT-GO/ Resin	6.50±0.18	172±7.3	3.1±0.11

Table 1. Flexural properties of the tested materials.

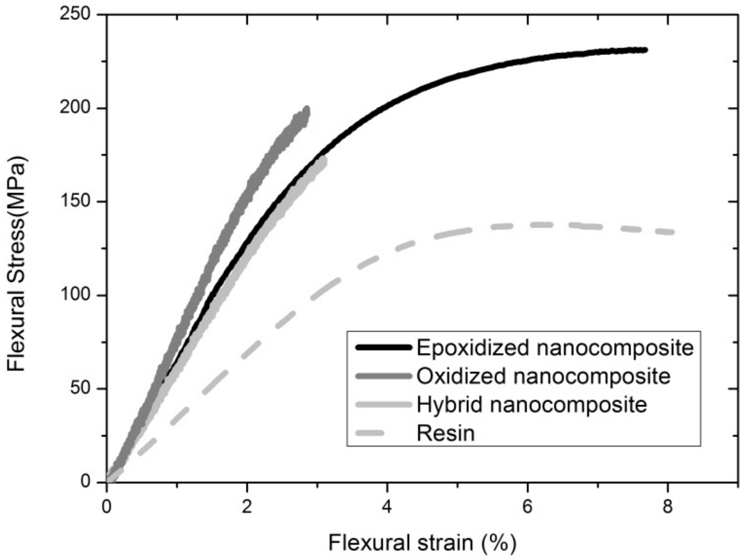

Figure 3. Stress-strain curves of resin and corresponding MWCNT nanocomposites from 3-point bending experiments.

4 Conclusions

Based on the buckypaper approach, MWCNT/epoxy composites were prepared and characterized. Depending on the modification treatment of CNTs, buckypapers with different textural properties were produced. These buckypaper formations give new impetus to the fabrication of nanocomposites with controlled porosity and, subsequently, volume fraction. The experimental results showed that the proposed fabrication scheme is an efficient way to improve substantially the mechanical response of MWCNT/resin composites. This fabrication procedure can be easily extended towards the preparation of laminated nanocomposites. The balancing of the various parameters such as the grafting ratio of functionalities onto the CNT surface, buckypaper porosity and prepregging at high pressures will lead to lightweight composite membranes for various applications.

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