EFFECT OF DISPERSION METHODS ON THE MECHANICAL AND ELECTROMAGNETIC PROPERTIES OF VGCF/EPOXY COMPOSITES

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1 Introduction

As a means to increase the mechanical and electrical permittivities of polymeric materials, nanocomposites containing conductive fillers such as carbon black, carbon nano fiber, carbon nano tube, and metallic nano powders are widely used [1]. Recently, the advancement of carbon nano materials such as carbon nano fiber (CNF), single-wall carbon nano tube (SWNT), multi-wall carbon nano tube (MWNT), including carbon black (CB), the representative traditional carbon nano material, provide us more flexibility of choice.

The VGCF (Vapor Grown Carbon Fiber) due to their high mechanical strength, modulus, and high electrical conductivity, in addition to the relatively low cost, is attracting significant attention for the reinforcement of nanocomposites. The nano-scale diameter and the great aspect ratio cause serious problems in mixing with the high viscous polymer matrices. It easily agglomerates when dispersed in the polymer, especially as the fiber content increases. This aggregate probably induces the non-uniformity in mechanical and electrical properties.

In this paper, we investigated the dispersion technique for VGCF into the epoxy resin and its influence on the mechanical and electromagnetic property

2 Experiments

2.1 Materials

2.1.1 VGCF

Commercially available VGCF (VGCF®-H), manufactured by Show Denko KK, were used in this study. VGCF®-H is the VGCF specifically designed to enhance the electrical and thermal properties of high performance materials. VGCF®-H is specially processed to improve dispersion and homogeneity. VGCF®-H have specific surface areas of 13 m^2/g, the diameter and the length of VGCF®-H are 150 nm and 10 ~ 20 μm, respectively. The real density and bulk density of VGCF®-H are 2.0 g/cm^3 and 0.04 g/cm^3, respectively.

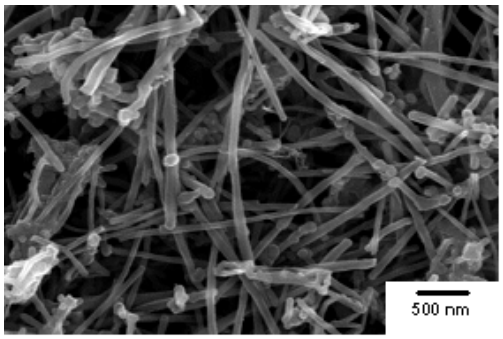

Fig. 1. SEM photo of VGCF®-H from Showa Denko KK(日)

Plasma treatment was applied to modify the surface of VGCF in order to increase the surface energy and wettability. As a result, the adhesion at the interface between VGCF and epoxy would be improved.

2.1.2 Epoxy matrix

The epoxy resin used in this study was diglycidyl ether of bisphenol A , YD-128 (Kukdo Chemical) processed with the anhydride curing agent, methyltetrahydrophthalic anhydride, MTHPA, Kukdo®, KBH-1089 (Kukdo Chemical). The mixing ratio of epoxy and curing agent was 100:90 weight ratio.

2.2 Fabrication of VGCF/Epoxy composites

To make the VGCF/anhydride-cured epoxy nanocomposites (up to 3 wt%), the VGCF were dispersed using beam-type sonicator or homogenizer at a speed of 10.000 rpm in ethanol for 30 minutes. The sonicator is the Sonic Mater® sonicator (The Sonic Tech, Co. Ltd) and the homogenizer is a Specification® homogenizer (Global Lab). The steps in the process are described in Fig. 2.

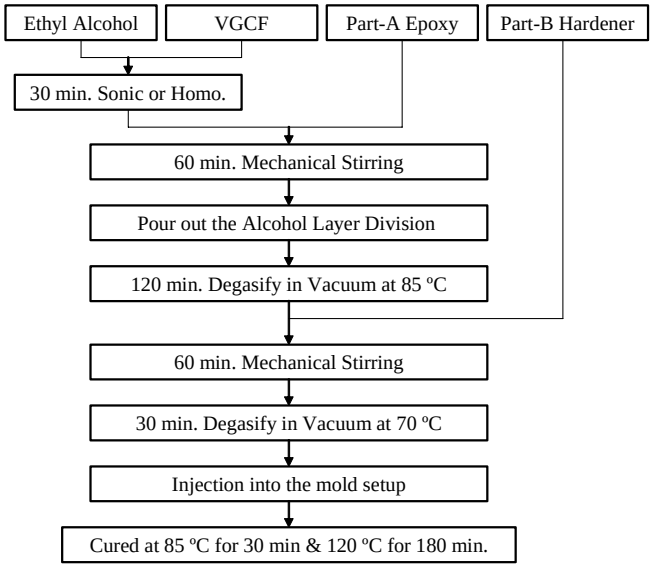

Fig. 2. The manufacturing process of VGCF/epoxy composite plates.

Fig. 3 shows the fracture surfaces of composites by tensile loading. In the figures, it is very hard to see the difference of dispersion in all the specimens and the VGCF can be considered to be well dispersed.

2 Material properties

2.1 Mechanical property

The tensile tests were performed based on ASTM D638 standard.

2.2 Electromagnetic property

In order to measure the complex permittivity at the microwave frequency band, Agilent N5230A (PNA-L Vector Network Analyzer) and 7 mm coaxial airline with Agilent N3696A (Electrical Calibration Module) were used. The specimens used for the complex permittivity measurements were machined out of composite plates so that the specimen could be inserted into the coaxial airline. The complex permittivity was obtained using Agilent 85071E (Material Measurement Software), in which the Nicolson-Ross-Weir method is implicated, from scattering parameters for reflected and transmitted TEM microwaves which were continuously measured from 0.5 GHz to 18 GHz.

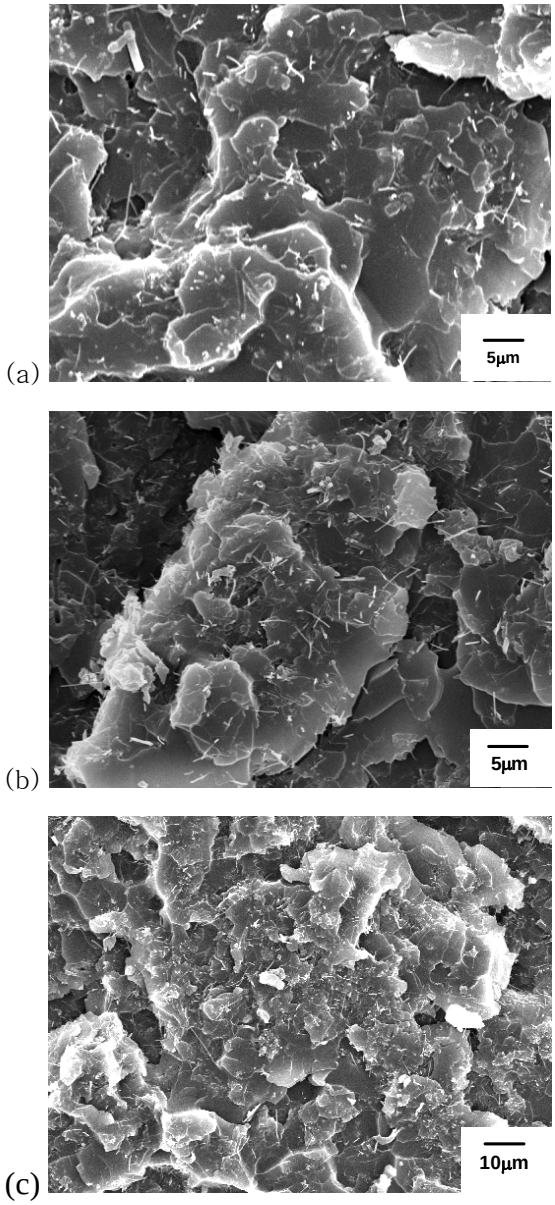

Fig. 3. SEM micrographs revealing fracture surfaces with 2.0 wt% VGCF contents. (a) with homogenizer method, raw VGCF, (b) with ultrasonic method, raw VGCF, (c) with sonic method, plasma treated VGCF.

References

[1] J.B. Kim, T.W. Kim, C.G. Kim, *J. Appl. Poly. Sci.* 100 (2006) p2189

[2] J.B. Javis et al, NIST Technical Note 1341, 1355-R