ENHANCEMENT OF MECHANICAL PROPERTIES OF EPOXY-BASED NANOCOMPOSITES USING HIGH MAGNETIC FIELDS

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Introduction

In the following is described, in summary outline, the results of initial experiments designed to investigate the influence of high uniform magnetic fields on the curing of a variety of composites comprising nanoparticles infused in simple epoxy matrices. The particulate components included quasi-spherical SiC, TiO_2, as well as carbon nanofibers and multi-walled carbon nanotubes. Significant improvements were observed for various elastic moduli as well as for thermal characteristics to a degree that indicated magnetic field-assisted ordering of the nanoparticles within the matrix.
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Experimental

The two magnet systems used here were in the DC Field Facility, (stations 7 and 8), both of which had 32 mm bores. The sample holders were PVC cylinders of approximate length 10cm and of (outer) diameter 31.5 mm. The length of the sample holder approximately matched in length the most uniform portion of the field. The majority of the samples comprised 1% nanoparticles by volume, dispersed in a fluid epoxy (SC-15) containing about 30% by volume of a room-temperature curing agent. This type of epoxy forms a gel after about 30 minutes, meaning that rather long exposures to high magnetic fields were required. Accordingly, exposure times of samples to the fields were typically in the range 1 to 3 hrs. A variety of field settings were also used, the lowest being 16 T, the highest 28 T.

Results and Discussion

Significant magnetic field enhancement of mechanical and thermal properties was found for all of the above-mentioned nanocomposites, although there was insufficient magnet time available, in the present round, for a complete understanding of the systematics of the process. Suffice to say that a 1 hr. field exposure was totally inadequate for all samples and 3 hrs. exposure barely adequate. Likewise, for SiC/TiO_2 composites, 16 T proved to be insufficient field. A summary of the mechanical improvements for the carbon nanofibers/nanotubes (only) is shown in Table 1. All of the data were obtained at a field of 21 T. Included in the table, for comparative purposes only, is the field enhancement data for a sample of neat epoxy (absent the nanoparticles).

Material	Magnetic Curing time (Hrs)	Compressive strength (MPa)	Gain/loss in strength (%)	Compressive modulus (MPa)	Gain/loss in modulus (%)
Neat SC-15	0	58.57	-	1.46	-
Neat SC-15	3	70.46	+20.3	2.17	+48.63
1%CNF	0	68.35	+16.7	2.19	+50.00
1%CNF	3	81.74	+39.56	2.26	+54.79
1%CNT	0	97.93	+67.2	2.69	+84.25
1%CNT	3	132.42	+126.09	3.89	+166.44

Table 1