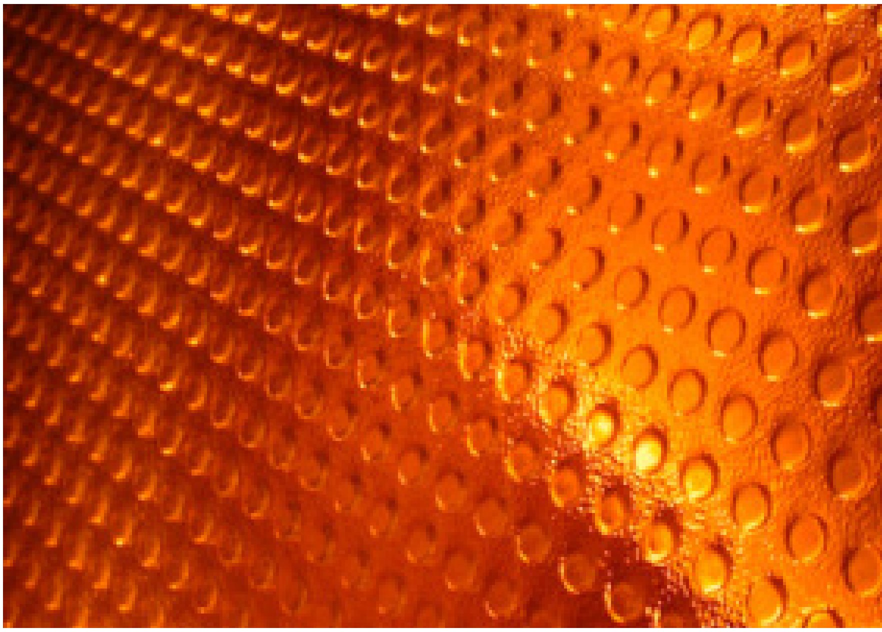

APPLICATION NOTE

Thermal Analysis

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Effect of Radiation on Epoxy and FeCr Filled Epoxy Composites

Introduction

The effects of radiation on polymeric materials is a topic of concern in a range of industries including the sterilization[1], medical devices[2], food preparation[3], and the nuclear power industry[4]. While much work has concentrated systems like polyolefins that are radiation sterilized[1], some work has been done on epoxy systems[5].

The use of fillers to attempt to protect the matrix from radiation is known[6] but to our knowledge has not been applied to epoxies. In this work, we use the ferrochromium alloy called ferrochrome (FeCr) as a filler and examine the effect of radiation on the polymer.

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Experimental

Samples of a commercial two-part epoxy (System 3) were prepared and blended with various levels by weight (50%, 60%, 70% and 80%) of 60 mesh FeCr powder. Specimens were then cured at 50 °C in silicon molds to make samples for DMA, mechanical testing, and rolling ball friction. After curing overnight, the samples were removed from the molds and post cured at 100 °C for 24 hours.

Dynamic Mechanical Analysis was performed using a PerkinElmer DMA8000 under nitrogen at 1 and 10 hertz. The glass transition temperature was taken as the peak of the tan delta at 1 hertz and the storage modulus was calculated at 20 °C. All data was run in triplicate and then averaged.

Tensile tests were done on a MTS Quest 5 Mechanical Testing using standard jaws at room temperature. Data was collected using multiple samples (5 or more) and averaged. Rolling ball scratch testing was also performed.

Samples were irradiated by the Department of Mechanical Engineering at the University of Bartin, Bartin, Turkey. Epoxy plaques from those molded above were exposed to alpha radiation at 25, 50 and 75 kilograys (kGy). Tests samples were cut from these plaques and tested as above.

Results

Table 1 summarizes the results from the DMA studies on FeCr filled epoxies samples before and after radiation. One should note the density of FeCr is considerably higher – approximately 5 times – of that of the epoxy and hence the volume fraction of filler is much lower than the weight percent used. Volume fractions were estimated using epoxy and FeCr densities from the respective MSDS sheets.

The DMA results suggest that the exposure to radiation causes degradation of the matrix epoxy, decreasing both the Tg and the storage modulus. Additions of FeCr appear to mitigate this affect. As the amount of FeCr increases, the modulus and the Tg decay less than the unfilled material.

Tensile tests are ongoing for the irradiated samples but those for the un-irradiated are reported below in Table 2 for modulus.

Friction results for 10 N and 20 N loads on the un-irradiated samples are shown in Figure 1. Irradiated samples are currently being tested.

Conclusion

From the data collected so far, it appears that additions of FeCr decrease the effect of radiation on the glass transition temperature and the storage modulus. Investigations continue on the tensile and friction properties.

Weight % FeCr	Volume % FeCr	Initial Tg	Initial Tg	75 kGy Irradiated Tg	75 kGy Irradiated E' at 25 C
0	0	62.6	9.40E+08	47.8	6.80E+08
50	11	63.0	1.90E+09	48.1	7.20E+08
60	14	64.0	2.40E+09	52.4	9.20E+08
70	16	61.8	2.60E+09	53.9	1.20E+09
80	18	63.2	2.70E+09	56.2	1.30E+09

Table 1. DMA results on epoxy blends

Weight % FeCr	Strain at break (%)	Modulus (MPa)	Elongation at break (mm)
0	4.98	1317.23	2.53
50	1.36	1081.87	0.69
60	1.36	984.76	0.70
70	1.45	781.84	0.75
80	1.83	769.89	0.93

Table 2. Tensile test results for pre-exposed epoxies

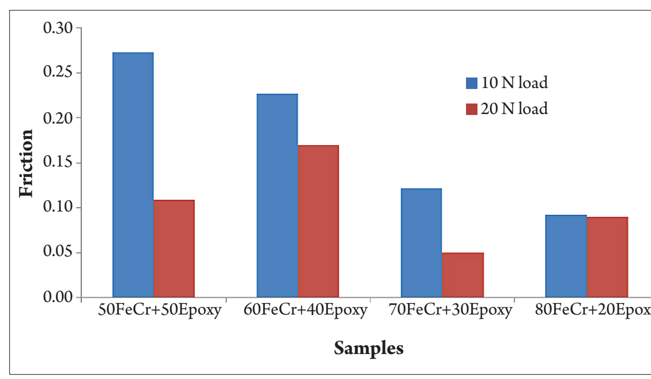

Figure 1. Un-irradiated sample resluts from rolling friction tests.

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