

High-Flow PMR-Polyimide Composites Developed With Mechanical Properties Comparable to Other High-Temperature Systems

PMR polyimides, in particular PMR-15, are well known for their excellent high-temperature stability and performance, and solvent resistance. However, the processing of these materials is limited, for the most part, to prepreg-based methods, such as compression or autoclave processing. These methods involve substantial amounts of hand labor, and as a result, manufacturing costs for components made from PMR polyimides can be high. In cost-sensitive applications, these high manufacturing costs can make the use of PMR polyimide-based components cost prohibitive.

Lower cost manufacturing methods, such as resin transfer molding (RTM) and resin film infusion, have been demonstrated to reduce manufacturing costs by as much as 50 percent over prepreg-based methods. However, these processes are only amenable to materials with melt viscosities below 30 poise. Most PMR polyimides have melt viscosities on the order of 100 poise or higher. Recent efforts at the NASA Glenn Research Center have focused on chemical modifications to PMR polyimides to reduce their melt viscosity to the point where they could be processed by these low-cost manufacturing methods without adversely affecting their high-temperature properties and performance.

These efforts have led to a new family of PMR polyimides that have melt viscosities significantly lower than that of PMR-15. Reductions in melt viscosity are brought about through the introduction of molecular twists in the polymer backbone. Carbon fiber (T650-35) composites were prepared from one of these polyimides, designated PMR-Flex, by compression molding. The properties of these composites are presented below and compared with comparable composites made from PMR-15 and PETI-RTM, a new low-melt-viscosity polyimide.

COMPARISON OF VARIOUS PROPERTIES OF PMR-FLEX COMPOSITES WITH THOSE OF PMR-15 AND PETI-RTM-BASED COMPOSITES

PMR-Flex ^a	PMR-15 ^a	PETI-RTM ^b
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Glass transition temperature, ^c °C	260	339	246
Flexural strength at room temperature, Mpa	1166±34	1001±68	889±59
Flexural modulus at room temperature	75.6±1.2	70.1±1.0	43.3±2.4
Short beam shear at room temperature, Mpa	70.8±2.1	66.2±1.5	61.0±3.9
Flexural strength at elevated temperature, ^d MPa	555±56	704±18	---
Flexural modulus at elevated temperature, ^d GPa	70.9±1.4	70.9±1.2	---
Short beam shear at elevated temperature, ^d MPa	36.8±2.5	40.5±1.8	---
Minimum melt viscosity, P	34	~2500	600
^a Laminates were eight plies reinforced with 8-HS, T650-35 carbon fabric.			
^b Laminates were four plies reinforced with 5-HS, IM-7 carbon fabric (data from ref. 1).			
^c Measured by DMA.			
^d PMR-Flex tested at 232 °C; PMR-15 tested at 288 °C.			

PMR-Flex had the lowest minimum melt viscosity of the three resins reported in the table. Room-temperature properties (flexural strength and modulus, and short beam shear) of the PMR-Flex composites were comparable to those of the PMR-15 composites and slightly higher than those of the PETI-RTM-based system (possibly due to the lower number of plies in the later). Also, results of PMR-Flex composite testing at 232 °C were compared with comparable properties of PMR-15 laminates at 288 °C. The lower test temperatures for the PMR-Flex laminates were chosen because of the lower glass-transition temperature of those laminates relative to that of the PMR-15 composites. Flexural and short beam shear strengths of PMR-Flex laminates were slightly lower than those of the PMR-15 composites. Efforts are underway to further modify this chemistry to increase the glass-transition temperature and elevated-temperature properties of these materials.

Find out more about the work of Glenn's Polymer Branch
(<http://www.grc.nasa.gov/WWW/MDWeb/5150/Polymers.html>)

Reference

1. Criss, J.M., et al.: SAMPE J., vol. 36, 2000, p. 32.

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