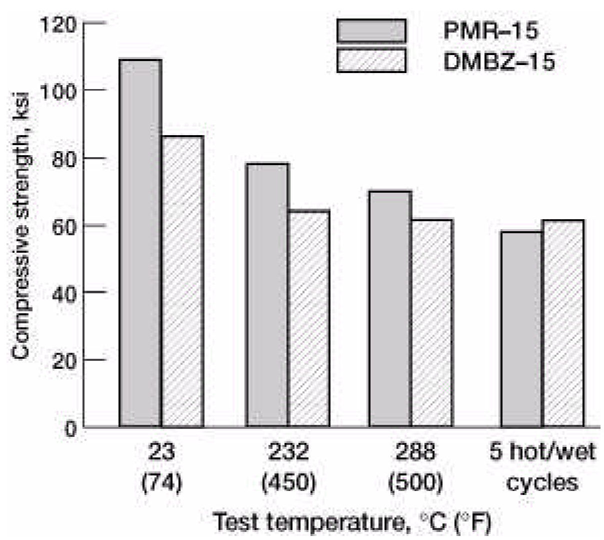
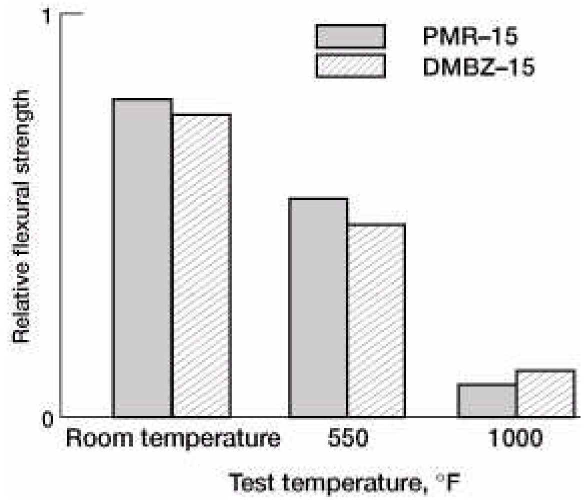
Low-Cost, High Glass-Transition Temperature, Thermosetting Polyimide Developed

PMR-15 polyimide, developed in the mid-1970’s at the NASA Lewis Research Center, is recognized as a state-of-the-art high-temperature resin for composite applications in the temperature range of 500 to 550 °F (260 to 288 °C). PMR-15 offers easy processing and good property retention at a reasonable cost. For these reasons, it is widely used in both military and commercial aircraft engine components. Traditionally, polyimide composites have been designed for long-term use at 500 to 600 °F over thousands of hours. However, new applications in reusable launch vehicles (RLV’s) require lightweight materials that can perform for short times (tens of hours) at temperatures between 800 and 1000 °F (425 and 538 °C). Current efforts at Lewis are focused on raising the use temperature of polyimide composites by increasing the glass-transition temperature of the matrix resins. Achieving this dramatic increase in the upper use temperature without sacrificing polymer and composite processability is a major technical challenge.



Compressive strength of polyimide/T650-35 composites.



Flexure strength of DMBZ-15 and PMR-15 composites.

A recent development from these efforts is a low-cost, high glass-transition temperature, thermosetting polyimide (DMBZ-15), prepared from 3,3',4,4'-benzophenonetetracarboxylic acid dimethyl ester (BTDE) and 2,2'-dimethylbenzidine (DMBZ) with nadic ester as the endcap. The glass-transition temperature of a DMBZ-15 polyimide/T650-35 carbon fiber composite (414 °C) is much higher than that of the corresponding PMR-15 composite (348 °C). DMBZ-15 polyimide-based composites exhibit good compressive strengths at room and elevated temperatures (233 and 288 °C), as well as good hot/wet compressive strength. (See the left figure, where one hot/wet cycle consists of a 93 °C (200 °F) water soak to a gain of >1 wt %, followed by a dry out at 288 °C (500 °F) to <0.1 wt % moisture.) In addition, flexural strengths of PMR-15 and DMBZ-15 composites measured at room temperature, 288 °C, and 538 °C are comparable (see the right figure). These materials, along with other high-performance fiber-reinforced polymer matrix composites are currently being evaluated in Lewis/industry/university/Government cooperative efforts for potential use in reusable launch vehicles (RLV's) and other space vehicles.

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