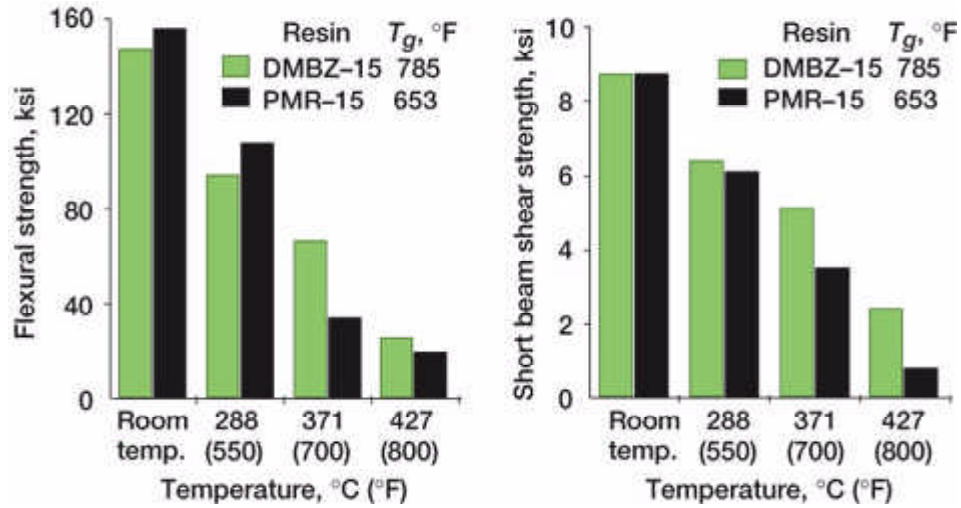


# Development of DMBZ-15 High-Glass-Transition-Temperature Polyimides as PMR-15 Replacements Given R&D 100 Award

PMR-15, a high-temperature polyimide developed in the mid-1970s at the NASA Lewis Research Center,<sup>1</sup> offers the combination of low cost, easy processing, and good high-temperature performance and stability. It has been recognized as the leading polymer matrix resin for carbon-fiber-reinforced composites used in aircraft engine components. The state-of-the-art PMR-15 polyimide composite has a glass-transition temperature ( $T_g$ ) of 348 °C (658 °F). Since composite materials must be used at temperatures well below their glass-transition temperature, the long-term use temperatures of PMR-15 composites can be no higher than 288 °C (550 °F). In addition, PMR-15 is made from methylene dianiline (MDA), a known liver toxin. Concerns about the safety of workers exposed to MDA during the fabrication of PMR-15 components and about the environmental impact of PMR-15 waste disposal have led to the industrywide implementation of special handling procedures to minimize the health risks associated with this material. These procedures have increased manufacturing and maintenance costs significantly and have limited the use of PMR-15 in commercial aircraft engine components.

Efforts at the NASA Glenn Research Center to develop a PMR-15 replacement have yielded an alternative polyimide, DMBZ-15, which has a  $T_g$  of 418 °C (784 °F). Because of its unusually high  $T_g$ , DMBZ-15 can be used at temperatures as high as 343 °C (650 °F) (see the bar charts). This is an increase of 55 °C (100 °F) over the maximum temperature of PMR-15, which is the current state of the art. In addition, DMBZ-15 composites have been shown to have wear resistance superior to that of PMR-15. Potential aerospace applications for this ultra-high-temperature composite include aircraft engine components--such as bushings and bearings, cases, ducts, and fuel and lubricant lines--as well as reusable-launch-vehicle (RLV) propulsion and airframe structures. Because of DMBZ's superior high-temperature stability and performance, use of this ultra-high-temperature composite in airframe components for RLVs would enable significant reductions in the thermal protection system (TPS) and its parasitic weight. Nonaerospace applications for DMBZ-15 include components for oil drilling equipment and replacements for oiled brass bearings in the rolling and printing industries.



*Elevated- and room-temperature mechanical properties of DMBZ-15 and PMR-15 T650-35 carbon fabric composites. T<sub>g</sub>, glass-transition temperature. Left: Flexural strength; Right: Short-beam shear strength.*

<sup>1</sup>Now called the NASA Glenn Research Center.

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