TOP3–00141

Resin Transfer Moldable Polyimides for High-Temperature Applications

Technology

The National Aeronautics and Space Administration seeks to transfer technology for the development and production of resin moldable polymides for high-temperature applications.

Benefits

- Melt viscosities low enough to enable RTM processing
- Stability and high-temperature properties necessary for operation at temperatures above 450 °F
- High specific strength and low density
- Reduce component and vehicle weight

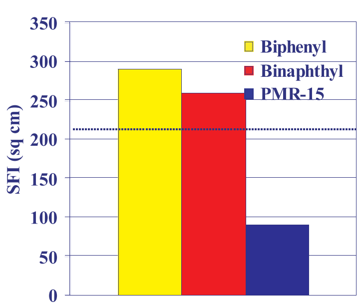
Commercial Applications

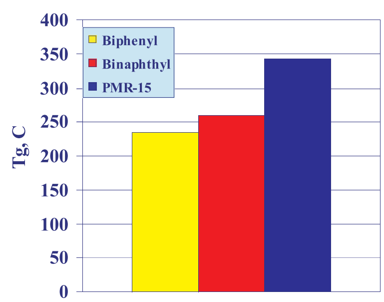
- Aircraft engine components
- Propulsion and airframe components for reusable launch vehicles

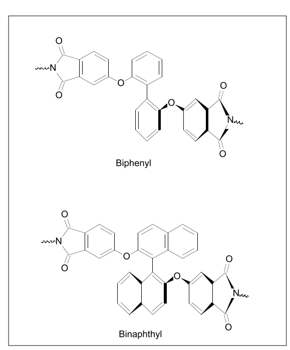
Technology Description

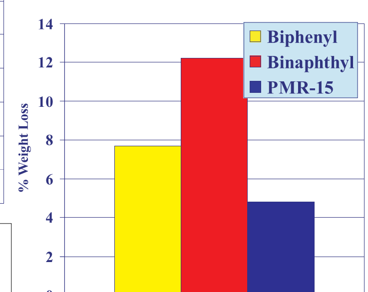
High-temperature polyimides, such as NASA Glenn-developed PMR–15, are becoming an increasingly important class of materials for a variety of aerospace applications. Typical methods for fabricating components from these high-temperature materials are fairly labor intensive and costly. More cost-effective methods, such as Resin Transfer Molding (RTM), have been developed and successfully employed with low-temperature polymers. The

Properties of Binaphthyl- and Biphenyl-Based Polyimide Neat Resins









1000 hours in air at 288 °C

challenge is to develop new polymers that have melt viscosities low enough to enable RTM processing and that have the stability and high-temperature properties necessary for operation at temperatures above 450 °F (232 °C).

Recent research has led to the development of a new family of PMR polyimides with melt viscosities low enough for RTM processing. Shown in the figure, from left to right, is a comparison of the Squeeze Flow Index, SFI (a measure of resin melt flow), glass transition temperature (Tg), and high temperature weight loss of two of these polyimides along with PMR–15.

Resin SFI's were measured by pressing 0.5 grams of a resin powder (sieved to a uniform particle size) between two sheets of Kapton in a heated press (550 °F, 260 °C) at 170 psi pressure, to produce resin blots. The area of these blots were measured by image analysis and are reported as SFI values (cm^2). Those resins with SFI values greater than 220 cm^2 have melt viscosities below 1000 cP, and should be suitable for RTM processing. The two resins in the bar chart on the left have SFI values that exceed the RTM target, while the SFI value for PMR–15 is about one-third that of the target value. PMR–15 has a melt viscosity in the neighborhood of 250,000 cP and cannot be processed by typical RTM methods.

Glass Transition Temperatures (center bar chart) for these two high flow PMR resins are close to 250 °C, lower than that of PMR–15. Weight losses after 1000 hr in air at 288 °C (550 °F) of these high flow resins were slightly higher that than of PMR–15 (right hand bar chart). A comparison of the mechanical properties of carbon fiber reinforced polymer matrix composites prepared with the biphenyl resin (High Flow PMR) and PMR–15 are shown in the table below. Room temperature properties of both of these composites are essentially equivalent. Elevated temperature (232 °C) properties of the high flow PMR composite were roughly 50 percent of the room temperature properties of this material.

Research is underway to improve the Tg and stability of these resins and composites prepared from them.

Options for Commercialization

NASA researchers are interested in continuing to develop this approach with those in industry and academia, and are seeking industrial partners to cooperatively develop additional applications for this new process.

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Reference

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Key Words

Polyimides

High temperature

Resin transfer molding

Melt viscosities

Property	PMR–15	High Flow PMR
Tg, °C	339	260
Fiber Content (wt. %)	63.9± 0.3	69.7±0.2
Flexural Strength, MPa (Room Temp)	1001±68	1166±34
Flexural Modulus, GPa (Room Temp)	70.1± 1.0	75.6±1.2
Short Beam Shear, MPa (Room Temp)	66.2±1.5	70.8±2.1
Flexural Strength, MPa[a] (High Temp)	704±18	555±56
Flexural Modulus, GPa[a] (High Temp)	70.9±1.2	70.9±1.4
Short Beam Shear, MPa[a] (High Temp)	40.5±1.8	36.8±2.5

[a]Test Temperature: PMR–15 = 288 °C, High Flow PMR = 232 °C