



The **G**lenn **A**lliance for **T**echnology **E**xchange is a partnership among NASA Glenn Research

Center, Battelle Memorial Institute, and the Ohio Aerospace Institute, whose purpose is to boost Ohio's economy by helping local companies turn NASA technologies into private-sector products.



Building Ohio's Aerospace Economy

The Ohio Aerospace Institute is a private nonprofit consortium of university, industry, and federal partners supporting collaborative efforts in aerospace research, education, and training. To date, OAI has managed more than \$150 million in collaborative activities aimed at building Ohio's aerospace economy.

Interested?

Under the auspices of the Glenn Alliance for Technology Exchange (GATE), OAI is in the process of putting together a consortium to collaborate in the evaluation of the commercialization potential of the high temperature RTM material. Aerospace firms' prime interest is using resin materials to produce components for their applications, but not sources of the material itself. Consortium activities will be focused on technical issues, defined by the consortium members themselves, which would enable the participants to move forward with their own specific applications. IP issues are addressed in a Joint Collaboration Agreement to enable a competitive advantage for the participants. Funding is cost shared among NASA (funds in place through an earmark) and the consortium members. Getting involved NOW gives consortium members an opportunity to influence the direction and specifics of the demonstration projects.

For more information about GATE and High Temperature PMC, contact:

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High Temperature Resin Transfer Molding (RTM) Resins

A low component manufacturing cost, solvent-free process for lightweight composites

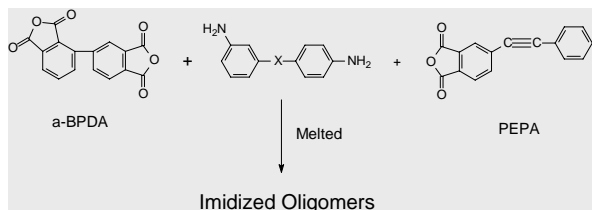


Executive Summary

Lightweight high temperature polymer matrix composites (PMC), reinforced with carbon fibers, have been the choice to replace alloys of aluminum, steel and titanium in aerospace components used for high temperature applications for decades. However, the cost of prepregs, hand lay-up and autoclave processes to produce complex parts, have been the drawbacks that prevent high temperature polyimide composites from its wide spread use like the bismaleimide (BMI) in the aerospace industry. A trade study indicated that if the composite fabrication could adopt low-cost processes such as resin transfer molding (RTM) or resin infusion (RI), it would save about 30% in the manufacturing cost of the polymer composites. The major advantage of RTM or RI over the traditional autoclave processing is the capability of fabricating complex shapes in one single injection operation into the preforms with desirable shapes. Previously, these RTM processes were usually reserved for use in the low temperature resins, such as epoxies and BMI, with 177°C and 232°C performance capabilities, respectively. Recently, NASA Glenn has developed a series of high T_g (glass transition temperature), low-melt viscosity (10-30 poise) imide resins that can be processed by RTM.

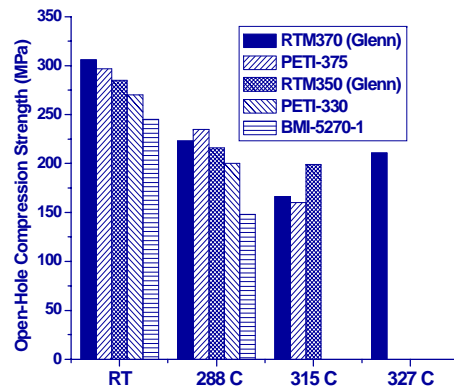
The resulting polyimide/carbon fiber composites have shown to exhibit excellent mechanical properties up to 327 °C (625 °F). Glenn's RTM370, essentially establishes it as the state-of-the-art RTM resins in the market today.

Why is the technology an advancement?



Advantages:

- No solvent was used
- Eliminated tedious and costly process of removing high boiling NMP solvent (BP= 202 °C)
- Capability exceeds BMI & PETI-330 in the market



Short beam shear strength of RTM resins based on a-BPDA vs. BMI-5270-1

NASA Glenn Research Center Expertise

The Polymer Branch of Materials Division at Glenn has a distinguished history in the development of high temperature polyimide composites since the invention of PMR-15 during the mid-70's. Researchers at Glenn are recognized and consulted as experts in the field of high temperature polymers and composites. The chemistry labs and processing facilities at Glenn are capable of conducting world class research in chemistry and high temperature resins as well as advanced fabrication techniques, including RTM process. The high temperature polymer composite has been the core competency of NASA Glenn since the invention of PMR-15 in the mid-70's. The recent success of low-melt imide resins developed at Glenn enables the high temperature polyimide composites to be processed by low-cost RTM or RI techniques.

Emerging Opportunities

Traditionally the fabrication of high temperature polyimide composites, such as PMR-15 relies on the prepregs and sometimes hand lay-up for complex shapes as well as autoclave process. These manufacturing processes are very costly and have prevented the polyimide composite from becoming a commodity. The trend in the aerospace community is to adopt low-cost manufacturing processes, such as resin transfer molding (RTM) or resin infusion (RI), in which a complex geometry of a desired part is constructed from a fiber perform and then the low-melt resins are injected into the mold followed by the cure of the resins. Trade studies indicate a potential 30% reduction in manufacturing cost by RTM or RI, and these processes could be easily automated. Glenn's low-melt resins present a brand new opportunity to simplify the process and lower the cost of fabricating high temperature composites that can potentially replace alloys of aluminum, steel and titanium in aerospace components.

How will the technology make industry more competitive?

- Provide RTM resins with 315 °C (600 °F) capability that exceed the state-of-the-art BMI (450 °F) and PETI-330 (500 °F) in high temperature performance
⇒ Better products, high premium in return
- Use low-cost RTM process that saves money and improves efficiency in manufacturing
⇒ Adaptable to automatic process

Potential Aerospace and Non-aerospace Applications include:

1. Lightweight polymer composites for airframe & engines components at 315 °C (600 °F)
2. JSF military & commercial aircrafts, space vehicles, missiles, rockets
3. High temperature laminates, wire coatings for electrical, transformer, electronic & automotive usage
4. Adhesives, prepregs based on new polyimides
5. Colorless polyimides for electronic and optical use
6. Bushings/bearing for oil drilling equipments

Findings from the recently completed cost analysis study based on the present formulation indicate that the estimated cost to produce the resin system in sample quantities is approximately \$450 per pound with further optimization possible. Use of alternative manufacturing processes for the resin system suggests the potential for reducing this to about \$150 per pound.