



Materials and Coatings

# A New Class of Strong and Flexible Carbon Fiber Reinforced Phenolic Composites

Fiber-Reinforced Composite Materials

NASA has filed a patent on a technology that creates a new class of phenolic and carbon fiber reinforced phenolic composites for thermal protection systems. The new materials have the advantage of being lightweight, strong, tough, yet heat resistant, and flexible. Their best characteristic is their remarkable capability to retain excellent mechanical strength at high temperatures. This provides better thermal protection for re-entry conditions with high heating rates. The materials incorporate thermoplastic polymer segments that are uniformly distributed throughout, and chemically bonded to the phenolic network. Phenolic resin polymers are a class of widely used thermosetting polymers. Their numerous advantages include excellent heat, radiation, corrosion/chemical resistances, and being flame retardant. They are low cost and have versatile processing/manufacturing methods.

## BENEFITS

- Lightweight, strong, and flexible
- Enhanced thermal protection for re-entry conditions with high heating rates
- Improved thermo-oxidation stability
- Can be used to fabricate flexible heat shields
- Increased incorporation of hydrogen, making it more resistant to solar radiation

technology solution



# NASA Technology Transfer Program

Bringing NASA Technology Down to Earth

## THE TECHNOLOGY

This unique approach modifies the phenolic polymer network by adding thermoplastic molecules with flexible segments such as aliphatic carbon and siloxane. The thermoplastic molecules are terminated with bifunctional groups that can directly react with the phenolic under the curing condition to form chemical bonds. Further incorporation of these segments can be facilitated by a relay reaction of a second molecular component which can bond with both the first flexible segments and the phenolic network. The selections of flexible, thermoplastic segments are based on desired properties, which include flexibility, ablative, an charring ability, heat resistance, and low catalycity.

The modified phenolic is a truly molecular composite in which flexible segments are connected with the phenolic network through strong chemical bonds and are uniformly distributed among the networks. This feature renders a uniform toughening/strengthening effect without compromising the lightweight nature of the materials. The process is also feasible to scale up and amenable for manufacturing.



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## APPLICATIONS

The technology has several potential applications:

- ➔ Space exploration
- ➔ Systems engineering
- ➔ Transportation industry
- ➔ Thermal Protection Systems
- ➔ Materials engineering

## PUBLICATIONS

Patent Pending

National Aeronautics and Space Administration

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