National Aeronautics and Space Administration

High-Performance Polyimide Insulation Technologies

Improved fire resistance from low-density foams

TECHNOLOGY OPPORTUNITY

Langley Research Center has developed a family of foams based on more than 25 innovative polyimide chemistries. The technology can take the form of foam or microspheres that can be used as additives. Langley refers to this technology, and associated international patents, as TEEK. The strong, low-density foam can be processed into neat or syntactic foams, foam-filled honeycomb, or other shapes, while offering excellent thermal and acoustic insulation and high-performance structural support. NASA has successfully licensed this technology, which has been used in naval vessels, and continues to offer non-exclusive licenses. Applications for the automotive industry include inflammable encasements for engines and muffler systems for sound compression.

BENEFITS

- Low thermal conductivity from cryogenic to elevated temperatures (see Figure 1)
- Flame (NHB 8060.1), chemical, solvent, and hot water resistant
- Low density ~0.008 g/cc (ASTM D-3574 [A])
- Highly resilient and durable with high compressive and tensile strength (see Figure 2)
- Low coefficient of thermal expansion (mm/mm-K at 24°C – 0.64 x e-5 to 0.89 x e-5)
- High glass transition temperature (DSC) – 237°C to 321°C
- Low dielectric constant – 1.026 to 2.125
- Hydrolytic stability and limiting oxygen index (42% to 51%)
- Ability to foam in place during installation and repair
- Nontoxic and nonfuming

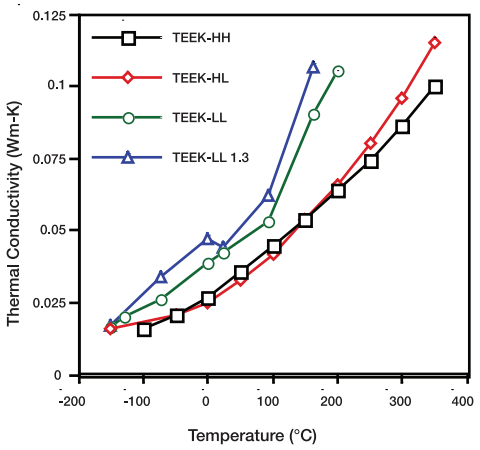
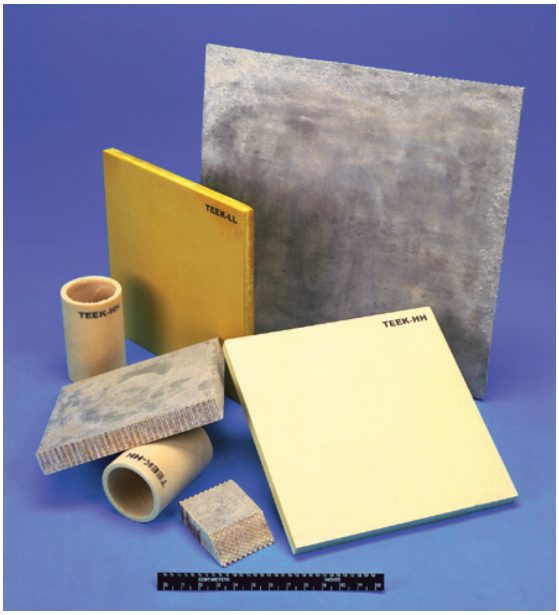


Figure 1: Thermal conductivity data for varied formulations/densities



COMMERCIAL APPLICATIONS

The technology offers wide-ranging market applications, including:

- Transportation – aerospace, aircraft, marine, automotive
- Industrial
- Construction
- Fire-resistant materials
- Improved insulation
- Soundproofing materials
- Honeycomb core replacement and filler
- Vibration damping pads
- Ablative components
- Abradable seals
- Water penetration barriers
- Radomes

TECHNOLOGY DESCRIPTION

NASA Langley developed the polyimide foam technology to meet an aerospace industry demand for high-performance structural foam with increased stiffness but without large weight increases that could operate over a large temperature regime -253°C to 232°C. The process for this foam begins with a monomeric solution with salt-like properties to yield a homogenous polyimide precursor solid residuum. The resulting precursor can be processed into polyimide neat or syntactic foams, microspheres, and filled structures like honeycomb. Each form enables production of useful articles through normal foaming techniques. Foam production is based on reacting a derivative of a dianhydride (e.g., ODPA, BTDA, PMDA) with a diamine (e.g., ODA, PDA, DDS). Foams can be fabricated to densities from 0.008 g/cc to 0.32 g/cc. Microspheres can be produced with diameters ranging from 100–1,500 microns. These microspheres can be used for foam-in-place applications or as additives to make less expensive materials more fire resistant.

NASA's foam technologies received these awards:

- 2003 Turning Goals into Reality award for Technology Innovation jointly with Kennedy Space Center, Lockheed Martin Michoud Space Systems, Boeing Huntington Beach, RTI, and Sordal.
- 2002 NASA LaRC Richard T. Whitcomb Award for Aerospace Technology Transfer
- 2001 R&D 100 Award

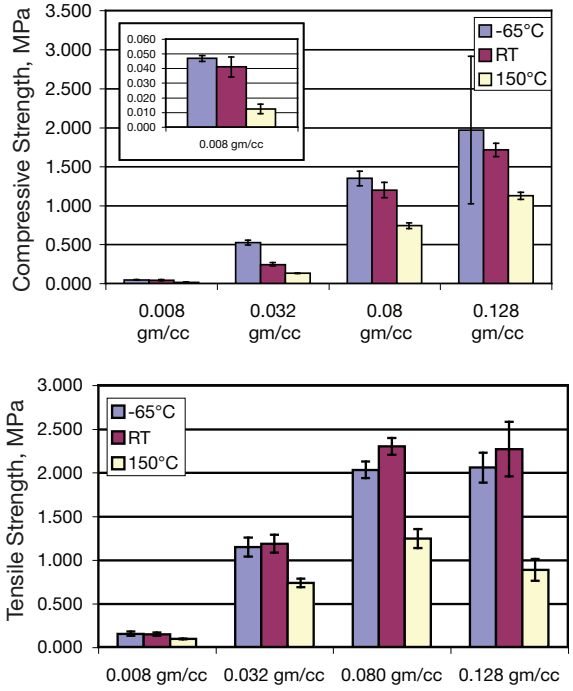


Figure 2: Compressive strength of TEEK-L foams (top) and flatwise tensile strength of TEEK-L foams (bottom). Tests performed by LaRC and Clark Atlanta University.

PATENTS

Relevant base patents:

- Aromatic Polyimide Foams, U.S. 6,133,330, Oct. 17, 2000; Japan JP3337695; EU Application 99928334.4
- Hollow Polyimide Microspheres, U.S. 5,994,418, Nov. 30, 1999; 6,084,000, July 4, 2000; U.S. 6,235,803, May 22, 2001; Japan JP3334890; EU Application 99935281.8
- Polyimide Precursor Solid Residuum, U.S. 6,180,746, Jan. 30, 2001; Japan JP3485936
- Films, Preimpregnated Tapes and Composites Made From Polyimide "Salt-Like" Solutions, U.S. 6,222,007, April 24, 2001; Japanese Application 11-557222

FOR MORE INFORMATION

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

The Technology Gateway

National Aeronautics and Space Administration
Langley Research Center
Mail Stop 218
Hampton, VA 23681
757.864.1178
LARC-DL-technologygateway@mail.nasa.gov
technologygateway.nasa.gov
www.nasa.gov

LAR-15977-1, LAR-15767-1, LAR-15831-1, LAR-15831-2, LAR-15831-3, LAR-15745-1