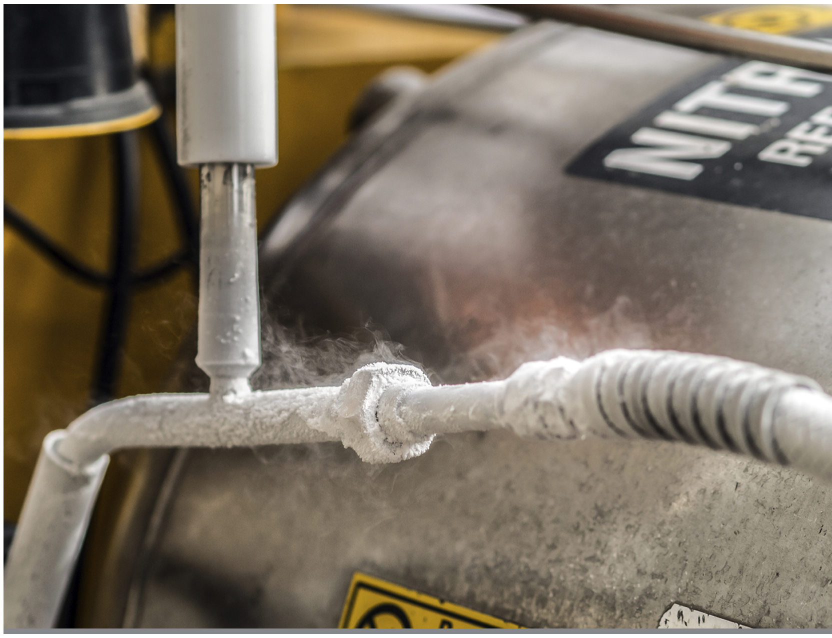


National Aeronautics and
Space Administration

TECHNOLOGY SOLUTION

Materials and Coatings

Polyamide Aerogels

State-of-the-art, highly flexible aerogel materials

Sometimes referred to as "solid smoke," aerogels are the world's lightest solid materials, composed of approximately 85% air by volume. Polyamide aerogels open up a whole new world of applications due to their unique properties: translucent like silica aerogels; thermoplastic; ultra-low density; superior mechanical properties; low-temperature operating range; and highly flexible (as compared to NASA Glenn's polyimide aerogels). Polyamide aerogels are further novel because of their tunable glass transition temperatures, meaning that crystallinity -- and hence strength -- can be controlled via operating temperature. Addressing the key drawbacks of aerogel technology (hydroscopicity, fragility, cost), NASA Glenn's suite of organic aerogels are cost-competitive with both existing silica aerogels and, with scale-up, high-end foamed polymer insulation. Finally, Glenn's materials are truly multi-functional -- they can be structural members while providing superior thermal properties and extremely low dielectric (near that of air).

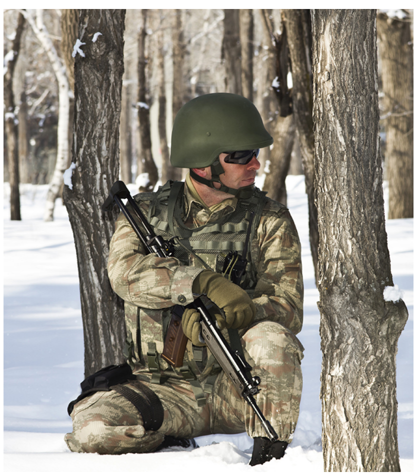
BENEFITS

- Versus silica aerogels: Weight, cost, flexibility, durability
- Versus polyimide aerogels: Flexibility, translucence
- Versus polymer foams: Thickness, performance

THE TECHNOLOGY

Polyamides are polymers that are similar to polyimides (another polymer that has been developed for use in aerogels). However, because the amide link is a single chain while the imide link is a ring structure, polyamide aerogels can be made less stiff than polyimides, even though a similar fabrication process is used. The precursor materials can be made from any combination of diamine and diacid chloride. Furthermore, NASA Glenn researchers have found methods for using combinations of diamines and disecondary amines to produce polyamide aerogels with tunable glass transition temperatures, for greater control of features such as flexibility or water-resistance.

In the first step of the fabrication process, an oligomeric solution is produced that is stable and can be prepared and stored indefinitely as stock solutions prior to cross-linking. This unique feature allows for the preparation and transport of tailor-made polyamide solutions, which can later be turned into gels via the addition of a small amount of cross-linker. When the cross-linking agent is added, the solution can be cast in a variety of forms such as thin films and monoliths. To remove the solvent, one or more solvent exchanges can be performed, and then the gel is subjected to supercritical drying to form a polyamide aerogel. NASA Glenn's polyamide aerogels can be fully integrated with the fabrication techniques and products of polyimide aerogel fabrication, so hybrid materials which have the properties of both classes are easily prepared. As the first aerogels to be composed of cross-linked polyamides, these materials combine flexibility and transparency in a way that sets them apart from all other polymeric aerogels.



Thin aerogels can serve as flexible insulation for gloves, boots, and outerwear.

Translucent aerogels can provide durable insulation for a variety of fabrics, including nylon and polyester.

APPLICATIONS

The technology has several potential applications:

- Construction (e.g., insulation)
- Garments (e.g., protective clothing)
- Appliances (e.g., better insulation in refrigerators)
- Camping gear (e.g., tents and sleeping bags)

PUBLICATIONS

Patent No: 10,011,719; 10,227,469; 10,787,569

Patent Pending

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

LEW-19053-1, LEW-19335-1, LEW-19053-2, LEW-19335-2, LEW-TOPS-31

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