Materials & Coatings

Polyurea-Based Aerogel Monoliths and Composites

These aerogels can be used in portable apparatus for warming, storing, and/or transporting food and medicine, and can be recycled for fillers for conventional plastics.

Lyndon B. Johnson Space Center, Houston, Texas

A flexible, organic polyurea-based aerogel insulation material was developed that will provide superior thermal insulation and inherent radiation protection for government and commercial applications. The rubbery polyurea-based aerogel exhibits little dustiness, good flexibility and toughness, and durability typical of the parent polyurea polymer, yet with the low density and superior insulation properties associated with aerogels. The thermal conductivity values of polyurea-based aerogels at lower temperature under vacuum pressures are very low and better than that of silica aerogels.

Flexible, rubbery polyurea-based aerogels are able to overcome the weak and brittle nature of conventional inorganic and organic aerogels, including polyisocyanurate aerogels, which are generally prepared with the one similar component to polyurethane rubber aerogels. Additionally, with higher content of hydrogen in their structures, the polyurea rubber-based aerogels will also provide inherently better radiation protection than those of inorganic and carbon aerogels. The aerogel materials also demonstrate good hydrophobicity due to their hydrocarbon molecular structure.

There are several strategies to overcoming the drawbacks associated with the weakness and brittleness of silica aerogels. Development of the flexible fiber-reinforced silica aerogel composite blanket has proven to be one promising approach, providing a conveniently fielded form factor that is relatively robust in industrial environments compared to silica aerogel monoliths. However, the flexible, silica aerogel composites still have a brittle, dusty character that may be undesirable, or even intolerable, in certain application environments. Although the cross-linked organic aerogels, such as resorcinol-formaldehyde (RF), polyisocyanurate, and cellulose aerogels, show very high impact strength, they are also very brittle with little elongation (i.e., less rubbery). Also, silica and carbon aerogels are less efficient radiation shielding materials due to their lower content of hydrogen element.

The invention involves mixing at least one isocyanate resin in solvent along with a specific amount of at least one polyamine hardener. The hardener is selected from a group of polyoxyalkyleneamines, amine-based polyols, or a mixture thereof. Mixing is performed in the presence of a catalyst and reinforcing inorganic and/or organic materials, and the system is then subjected to gelation, aging, and supercritical drying. The aerogels will offer exceptional flexibility, excellent thermal and physical properties, and good hydrophobicity.

The rubbery polyurea-based aerogels are very flexible with no dust and hydrophobic organics that demonstrated the following ranges of typical properties: densities of 0.08 to 0.293 g/cm^3, shrinkage factor (raerogel/rtarget) = 1.6 to 2.84, and thermal conductivity values of 15.2 to 20.3 mW/m K.

This work was done by Je Kyun Lee of Aspen Aerogels, Inc. for Johnson Space Center. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Aspen Aerogels, Inc.
30 Forbes Road, Building B
Northborough, MA 01532
Phone No.: (508) 691-1111
Fax No.: (508) 691-1200

Refer to MSC-24214-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Resin-Impregnated Carbon Ablator: A New Ablative Material for Hyperbolic Entry Speeds

From surface temperatures as high as ≈3,000 °C, the measured back temperature is only 50 °C.

Goddard Space Flight Center, Greenbelt, Maryland

Ablative materials are required to protect a space vehicle from the extreme temperatures encountered during the most demanding (hyperbolic) atmospheric entry velocities, either for probes launched toward other celestial bodies, or coming back to Earth from deep space missions. To that effect, the resin-impregnated carbon ablator (RICA) is a high-temperature carbon/phenolic ablative thermal protection system (TPS) material designed to use modern and commercially viable components in its manufacture. Heritage carbon/phenolic ablators intended for this use rely on materials that are no longer in production (i.e., Galileo, Pioneer Venus); hence the development of alternatives such as RICA is necessary for future NASA planetary entry and Earth re-entry missions. RICA's capabilities were initially measured in air for Earth re-entry applications, where it was exposed to a heat