



## Improved Aerogel Vacuum Thermal Insulation

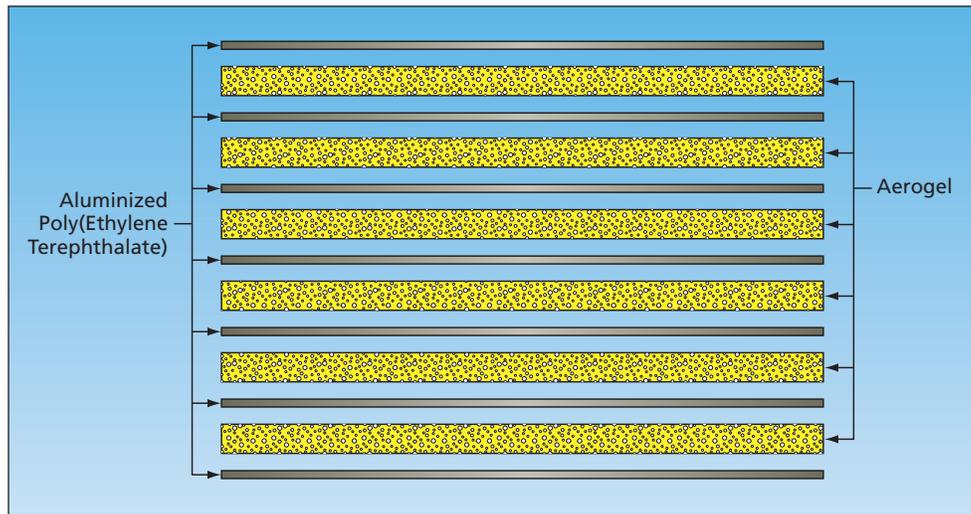
Multilayer structures offer reduced effective thermal conductivity.

Lyndon B. Johnson Space Center, Houston, Texas

An improved design concept for aerogel vacuum thermal-insulation panels calls for multiple layers of aerogel sandwiched between layers of aluminized Mylar (or equivalent) poly(ethylene terephthalate), as depicted in the figure. This concept is applicable to both the rigid (brick) form and the flexible (blanket) form of aerogel vacuum thermal-insulation panels.

Heretofore, the fabrication of a typical aerogel vacuum insulating panel has involved encapsulation of a single layer of aerogel in poly(ethylene terephthalate) and pumping of gases out of the aerogel-filled volume. A multilayer panel according to the improved design concept is fabricated in basically the same way: Multiple alternating layers of aerogel and aluminized poly(ethylene terephthalate) are assembled, then encapsulated in an outer layer of poly(ethylene terephthalate), and then the volume containing the multilayer structure is evacuated as in the single-layer case.

The multilayer concept makes it possible to reduce effective thermal conductivity of a panel below that of a compar-



An Improved Aerogel Vacuum Insulation Panel contains multiple layers of aerogel interspersed with layers of aluminized poly(ethylene terephthalate). The panel is shown here in the uncompressed form at an intermediate stage of fabrication. Once the interior of the panel is evacuated, exterior atmospheric pressure squeezes the layers together.

able single-layer panel, without adding weight or incurring other performance penalties. Implementation of the multilayer concept is simple and relatively inexpensive, involving only a few additional fabrication steps to assemble the multiple layers prior to evacuation. For a

panel of the blanket type, the multilayer concept, affords the additional advantage of reduced stiffness.

*This work was done by Warren P. Ruemele and Grant C. Bue of Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-24351-1*

## Fluoroester Co-Solvents for Low-Temperature Li<sup>+</sup> Cells

Both low-temperature performance and high-temperature resilience are improved.

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Electrolytes comprising LiPF<sub>6</sub> dissolved in alkyl carbonate/fluoroester mixtures have been found to afford improved low-temperature performance and greater high-temperature resilience in rechargeable lithium-ion electrochemical cells. These and other electrolytes comprising lithium salts dissolved mixtures of esters have been studied in continuing research directed toward extending the lower limit of operating temperatures of such cells. This research at earlier stages, and the un-

derlying physical and chemical principles, were reported in numerous previous NASA Tech Briefs articles.

The purpose of the present focus on high-temperature resilience in addition to low-temperature performance is to address issues posed by the flammability of the esters and, at temperatures near the upper end (about 55 °C) of their intended operating temperature range, by their high chemical reactivity. As used here, "high-temperature resilience" signifies, loosely, a desired combination of

low flammability of an electrolyte mixture and the ability of a cell that contains the mixture to sustain a relatively small loss of reversible charge/discharge capacity during storage in the fully charged condition at high temperature. The selection of fluoroesters for study as candidate electrolyte solvent components to increase high-temperature resilience was prompted in part by the observation that like other halogenated compounds, fluoroesters have low flammability.

The fluoroesters investigated in this study include trifluoroethyl butyrate (TFEB), ethyl trifluoroacetate (ETFA), trifluoroethyl acetate (TFEA), and methyl pentafluoropropionate (MPFP). Solvent mixtures were prepared by mixing these fluoroesters with two other esters: ethylene carbonate (EC) and ethyl methyl carbonate (EMC). The specific solvent mixtures were the following:

- IEC + 3EMC + 1TFEB
- IEC + 2EMC + 2TFEB
- IEC + 1EMC + 3TFEB
- IEC + 3EMC + 1ETFA
- IEC + 2EMC + 2TFEA
- IEC + 3EMC + 1TFEA
- IEC + 3EMC + 1MPFP

where the numbers indicate the relative volume proportions of the constituents.

Electrolytes were prepared by dissolving  $\text{LiPF}_6$  at a concentration of 1.0 M in these solvents. In addition, baseline (non-fluoroester-containing) electrolytes were prepared by dissolving  $\text{LiPF}_6$  at a concentration of 1.0 M in the following solvent mixtures:

- IEC + 1DEC + 1DMC
- IEC + 4EMC

where "DEC" signifies diethyl carbonate and "DMC" signifies dimethyl carbonate.

Rechargeable carbonanode/ $\text{LiNi}_{0.8}\text{Co}_{0.2}\text{O}_2$ -cathode cells containing these electrolytes were assembled and subjected to charge-discharge cycling tests at various temperatures from room temperature (23 °C) down to -60 °C. The cells were also evaluated with respect to high-temperature re-

silience by measuring the fractions of initial reversible capacity retained after storage for 10 days at a temperature of 55 °C. In these tests, the cell containing the electrolyte 1.0 M  $\text{LiPF}_6$  in (1EC + 3EMC + 1TFEB) exhibited the greatest overall improvements in both low-temperature performance (see figure) and high-temperature resilience over the cells containing the baseline electrolytes.

*This work was done by Marshall Smart, and Ratnakumar Bugga of Caltech and G. K. Surya Prakash, Kiah Smith, and Pooja Bhalla of the University of Southern California for NASA's Jet Propulsion Labo-*

*ratory. 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:*

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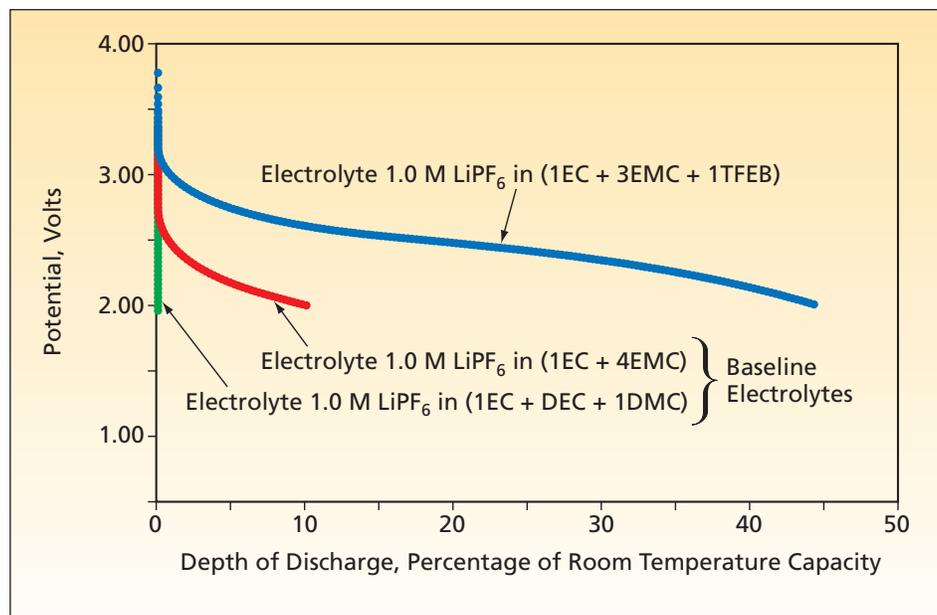
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**Potentials of Cells** containing various electrolytes were measured at a temperature of -60 °C during discharge at a current of 10 mA to a final potential of 2.0 V.

## Using Volcanic Ash To Remove Dissolved Uranium and Lead

Lyndon B. Johnson Space Center, Houston, Texas

Experiments have shown that significant fractions of uranium, lead, and possibly other toxic and/or radioactive substances can be removed from an aqueous solution by simply exposing the solution, at ambient temperature, to a treatment medium that includes weathered volcanic ash from Pu'u Nene, which is a cinder cone on the Island of Hawaii. Heretofore, this specific volcanic ash has been used for an entirely different purpose: simulating the spectral properties of Martian soil.

The treatment medium can consist of the volcanic ash alone or in combination

with chitosan, which is a natural polymer that can be produced from seafood waste or easily extracted from fungi, some bacteria, and some algae. The medium is harmless to plants and animals and, because of the abundance and natural origin of its ingredient(s), is inexpensive. The medium can be used in a variety of ways and settings: it can be incorporated into water-filtration systems; placed in contact or mixed with water-containing solids (e.g., soils and sludges); immersed in bodies of water (e.g., reservoirs, lakes, rivers, or wells); or placed in and around nuclear power plants, mines, and farm fields.

*This work was done by David S. McKay of Johnson Space Center and Raul G. Cuero of Prairie View A&M University. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

*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:*

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