The use of higher concentrations of the flame-retardant additive is known to reduce the flammability of the electrolyte solution, with 15% concentration resulting in solutions of substantially reduced flammability. Thus, the desired concentration of the flame-retardant additive is the greatest amount tolerable without adversely affecting the performance in terms of reversibility, ability to operate over a wide temperature range, and the discharge rate capability. The use of FEC was used to reduce the inherent flammability of mixtures and improve the compatibility at the interfacial regions, due to desirable surface reactions.

This work was done by Marshall C. Smart and Ratnakumar V. Bugga of Caltech, and G.K. Surya Prakash and Frederick C. Krause of the University of Southern California for NASA's Jet Propulsion Laboratory. 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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Refer to NPO-47980, volume and number of this NASA Tech Briefs *issue, and the page number.*

Polymer-Reinforced, Non-Brittle, Lightweight Cryogenic Insulation

John F. Kennedy Space Center, Florida

The primary application for cryogenic insulating foams will be fuel tank applications for fueling systems. It is crucial for this insulation to be incorporated into systems that survive vacuum and terrestrial environments. It is hypothesized that by forming an open-cell silica-reinforced polymer structure, the foam structures will exhibit the necessary strength to maintain shape. This will, in turn, maintain the insulating capabilities of the foam insulation. Besides mechanical stability in the form of crush resistance, it is important for these insulating materials to exhibit water penetration resistance. Hydrocarbon-terminated foam surfaces were implemented to impart hydrophobic functionality that apparently limits moisture penetration through the foam. During the freezing process, water accumulates on the surfaces of the foams. However, when hydrocarbon-terminated surfaces are present, water apparently beads and forms crystals, leading to less apparent accumulation.

The object of this work is to develop inexpensive structural cryogenic insulation foam that has increased impact resistance for launch and ground-based cryogenic systems. Two parallel approaches will be pursued: a silica-polymer co-foaming technique and a post foam coating technique.

Insulation characteristics, flexibility, and water uptake can be fine-tuned through the manipulation of the polyurethane foam scaffold. Silicate coatings for polyurethane foams and aerogel-impregnated polyurethane foams have been developed and tested. A highly porous aerogel-like material may be fabricated using a co-foam and coated foam techniques, and can insulate at liquid temperatures using the composite foam.

NASA is currently involved with varying space and terrestrial projects that would greatly benefit from more efficient cryogenic insulation to reduce fuel boil-off. Hydrogen quality testing methods require terrestrial sampling lines that would benefit from this insulation by reducing line losses for more accurate representation of tank holdings. Moreover, rockets and orbital depot systems require insulation that will maintain liquid fuel during liftoff, and during the initiation of orbit.

This work was done by David M. Hess of InnoSense LLC for Kennedy Space Center. For more information, contact the Kennedy Space Center Innovative Partnerships Office at (321) 867-5033. KSC-13569

Controlled, Site-Specific Functionalization of Carbon Nanotubes With Diazonium Salts

Possible applications include molecular switches and molecular wires.

Lyndon B. Johnson Space Center, Houston, Texas

This work uses existing technologies to prepare a crossbar architecture of nanotubes, wherein one nanotube is fixed to a substrate, and a second nanotube is suspended a finite distance above. Both nanotubes can be individually addressed electrically. Application of opposite potentials to the two tubes causes the top tube to deform and to essentially come into contact with the lower tube. Contact here refers not to actual, physical contact, but rather within an infinitesimally small distance referred to as van der Walls contact, in which the entities may influence each other on a molecular and electronic scale.

First, the top tube is physically deformed, leading to a potentially higher chemical reactivity at the point of deformation, based on current understanding of the effects of curvature strain on reactivity. This feature would allow selective functionalization at the junction via reaction with diazonium salts. Secondly, higher potential is achieved at the point of "cross" between the tubes. In a pending patent application, a method is claimed for directed self-assembly of molecular components onto the surface of metal or conductive materials by application of potential to the metal or conductive surface. In another pending