patent application, a method is claimed for attaching molecules to the surface of nanotubes via the use of reactive diazonium salts. In the present invention, the directed functionalization of the crossed-nanotube junctions by applying a potential to the ends of the nanotubes in the presence of reactive diazonium slats, or other reactive molecular species is claimed.

The diazonium salts are directed by the potential existing at the junction to react with the surface of the nanotube, thus placing functional molecular components at the junctions. The crossed nanotubes therefore provide a method of directly addressing the functionalized molecules, which have been shown to function as molecular switches, molecular wires, and in other capacities and uses. Site-specific functionalization may enable the use of nanotubes in molecular electronic applications because device functionality is critical at the cross points.

This work was done by James M. Tour of Rice University for Johnson Space Center. 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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Refer to MSC-24050-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Regenerable Sorbent for CO_2 Removal

Marshall Space Flight Center, Alabama

A durable, high-capacity regenerable sorbent can remove CO_2 from the breathing loop under a Martian atmosphere. The system design allows near-ambient temperature operation, needs only a small temperature swing, and sorbent regeneration takes place at or above 8 torr, eliminating the potential for Martian atmosphere to leak into the regeneration bed and into the breathing loop. The physical adsorbent can be used in a metabolic, heat-driven TSA system to remove CO_2 from the breathing loop of the astronaut and reject it to the Martian atmosphere. Two (or more) alternating sorbent beds continuously scrub and reject CO_2 from the spacesuit ventilation loop. The sorbent beds are cycled, alternately absorbing CO_2 from the vent loop and rejecting the adsorbed material into the environment at a high CO_2 partial pressure (above 8 torr). The system does not need to run the adsorber at cryogenic temperatures, and uses a much smaller temperature swing.

The sorbent removes CO_2 via a weak chemical interaction. The interaction is strong enough to enable CO_2 adsorption even at 3 to 7.6 torr. However, because the interaction between the surface adsorption sites and the CO_2 is relatively weak, the heat input needed to regenerate the sorbent is much lower than that for chemical absorbents.

The sorbent developed in this project could potentially find use in a large commercial market in the removal of CO_2 emissions from coal-fired power plants, if regulations are put in place to curb carbon emissions from power plants.

This work was done by Gokhan Alptekin and Ambal Jayaraman of TDA Research for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32902-1

Sprayable Aerogel Bead Compositions With High Shear Flow Resistance and High Thermal Insulation Value

This aerogel insulation could be used in fuel cell systems, oil and gas pipelines, and in building and construction applications.

Marshall Space Flight Center, Alabama

A sprayable aerogel insulation has been developed that has good mechanical integrity and lower thermal conductivity than incumbent polyurethane spray-on foam insulation, at similar or lower areal densities, to prevent insulation cracking and debonding in an effort to eliminate the generation of inflight debris.

This new, lightweight aerogel under bead form can be used as insulation in various thermal management systems that require low mass and volume, such as cryogenic storage tanks, pipelines, space platforms, and launch vehicles. These aerogel beads, with a packing density of 0.03 to 0.05 g/cm^3, can be used as pour-in, formable, or sprayable insulation, showing versatility in a variety of applications.

Silica and organically modified silica aerogel beads in a mixture with binders or foams can be formed into complex shapes, or sprayed onto panels. The aerogel composites have a fast cure, and have good mechanical strength at densities of 0.05 to 0.15 g/cm^3. Compression modulus for the aerogel bead/foam composite was 60 percent higher than the one from the foam without aerogel dopant.

Lightweight aerogel beads can be used in sprayable form together with a carrier for on-site applications. The sprayable thermal insulator has several advantages, such as a large temperature range of operation (from cryogenic temperatures to +300 °C), facile on-site installation, can be cured at room temperature, is mechanically robust and durable, and has excellent thermal performance insulation capability. This innovation is also water repellent, but does not trap gases or cryogenic liquids and, consequently, does not pose cryopumping and cryoingestion problems.

This thermal management system can be applied in either an automated or manual spraying process with less sensitivity to process chemistry and environmental parameters than spray-on foam insulation (SOFI) products like a commercially produced polyurethane foam used on the Space Shuttle External Tank, while providing better insulation performance. The aerogel bead binder-sprayed panel, with a thermal conductivity of 20 to 25 mW/mK, outperformed the commercial foam by 30 to 40 percent in the 10 to 100 °C temperature range.

The aerogel compositions developed for this innovation withstand repeated cycles of high enthalpy shear flows of 20 to 100 Pa at temperatures tested up to 370 °C without losing mechanical integrity. Thermal management systems with versatile installation based on aerogel beads represent a significant opportunity for improving performance of systems for long-term cryogenic propellant storage or transfer for mechanisms operating in cryogenic temperature environments, space transportation, and propulsion systems.

This work was done by Danny Ou, Roxana Trifu, and Gregory Caggiano of Aspen Aerogels, Inc. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32810-1.