Sequestration of Single-Walled Carbon Nanotubes in a Polymer

The nanotubes would be solubilized for incorporation into lightweight composites.

Lyndon B. Johnson Space Center, Houston, Texas

Sequestration of single-walled carbon nanotubes (SWCNs) in a suitably chosen polymer is under investigation as a means of promoting the dissolution of the nanotubes into epoxies. The purpose of this investigation is to make it possible to utilize SWCNs as the reinforcing fibers in strong, lightweight epoxy-matrix/carbon-fiber composite materials. SWCNs are especially attractive for use as reinforcing fibers because of their stiffness and strength-to-weight ratio: Their Young’s modulus has been calculated to be 1.2 TPa, their strength has been calculated to be as much as 100 times that of steel, and their mass density is only one-sixth that of steel.

Bare SWCNs cannot be incorporated directly into composite materials of the types envisioned because they are not soluble in epoxies. Heretofore, SWCNs have been rendered soluble by chemically attaching various molecular chains to them, but such chemical attachments compromise their structural integrity.

In the method now under investigation, carbon nanotubes are sequestered in molecules of poly(m-phenylenevinylene-co-2,5-dioctyloxy-p-phenylenevinylene) [PmPV]. The strength of the carbon nanotubes is preserved because they are not chemically bonded to the PmPV. At the assigned position on the planet, the compacted tank would be heated above $T_g$ by the solar radiation making it rebound to its original size and shape. Finally, the tank would be rigidified through natural cooling to below $T_g$ in the planetary ambient environment.

This work was done by Witold Sokolowski and Kaushik Bhattacharya of Caltech for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

NPO-43479
ists a favorable interface between the conjugated face of a nanotube and the conjugated backbone of the polymer and partly because of the helical molecular structure of PmPV. The constituents attached to the polymer backbones (the side chains) render the PmPV-wrapped carbon nanotubes PmPV soluble in organic materials that, in turn, could be used to suspend the carbon nanotubes in epoxy precursors.

At present, this method is being optimized: The side chains on the currently available form of PmPV are very nonpolar and unable to react with the epoxy resins and/or hardeners; as a consequence, SWCN/PmPV composites have been observed to precipitate out of epoxies while the epoxies were being cured. If the side chains of the PmPV molecules were functionalized to make them capable of reacting with the epoxy matrices, it might be possible to make progress toward practical applications.

By bonding the side chains of the PmPV molecules to an epoxy matrix, one would form a PmPV conduit between the epoxy matrix and the carbon nanotubes sequestered in the PmPV. This conduit would transfer stresses from the epoxy matrix to the nanotubes. This proposed load-transfer mode is similar to that of the current practice in which silane groups are chemically bonded to both the epoxy matrices and the fibers (often glass fibers) in epoxy-matrix/fiber composites.

This work was done by Richard A. Bley of Eltron Research 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:

Eltron Research Inc.
4600 Nautilus Court South
Boulder, CO 80301-3241

Refer to MSC-23257, volume and number of this NASA Tech Briefs issue, and the page number.