

single-walled carbon nanotubes, relative to all forms of carbon (including carbon fibers, multi-walled carbon nanotubes, and graphite) produced in the disproportionation reaction is more than 90 weight percent. After the reaction, the nanotubes are dispersed in various solvents in preparation for end use, which typically involves blending into a plastic, ceramic, or other matrix to form a composite material.

Notwithstanding the batch nature of the unmodified prior fluidized-bed process, the fluidized-bed reactor operates in a continuous mode during the process. The operation is almost entirely automated, utilizing mass flow controllers, a control computer running software specific to the process, and other equipment. Moreover, an important inherent advantage of fluidized-bed reactors in general is that solid particles can be added to and re-

moved from fluidized beds during operation. For these reasons, the process and equipment were amenable to modification for conversion from batch to continuous production.

The improvements include the following:

- A provision has been made for continuous addition of catalyst particles by entraining them in a stream of helium that is fed into the reactor.
- Progress has been made toward implementation of a purification/suspension post-process.
- Progress has also been made toward implementation of an alternative purification process that involves the use of hydrofluoric acid.
- A post-purification drying method was invented. This method increases the probability of success of subsequent efforts to re-disperse lyophilized samples of purified product material.

- Techniques of *in-situ* polymerization were explored. The findings may lead to development of strong, lightweight carbon-nanotube/polymer composites.

This work was done by Leandro Balzano and Daniel E. Resasco of SouthWest Nano Technologies, Inc., for Johnson Space Center. For more information, see www.swnano.com.

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-23706-1, volume and number of this NASA Tech Briefs issue, and the page number.

Progress Toward Sequestering Carbon Nanotubes in PmPV

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A report reopens the discussion of "Sequestration of Single-Walled Carbon Nanotubes in a Polymer" (MSC-23257), *NASA Tech Briefs*, Vol. 31, No. 12 (December 2007), page 38. To recapitulate: Sequestration of single-walled carbon nanotubes (SWNTs) in molecules of poly(*m*-phenylenevinylene-co-2,5-dioctyloxy-*p*-phenylenevinylene) [PmPV] is a candidate means of promoting dissolution of single-walled carbon nanotubes (SWNTs) into epoxies for making strong, lightweight epoxy-matrix/carbon-fiber composite materials. Bare SWNTs cannot be incorporated because they are not soluble in epoxies. One can render SWNTs soluble by chemically at-

taching various molecular chains to them, but such chemical attachments weaken them. In the present approach, one exploits the tendency of PmPV molecules to wrap themselves around SWNTs without chemically bonding to them. Attached to the backbones of the PmPV molecules are side chains that are soluble in, and chemically reactive with, epoxy precursors, and thus enable suspension of SWNTs in epoxy precursors. At time of the cited prior article, there had been only partial success in functionalizing the side chains to make them sufficiently soluble and reactive. The instant report states that a method of functionalization has been developed.

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:

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