Formulating Precursors for Coating Metals and Ceramics

John H. Glenn Research Center, Cleveland, Ohio

A protocol has been devised for formulating low-vapor-pressure precursors for protective and conversion coatings on metallic and ceramic substrates. The ingredients of a precursor to which the protocol applies include additives with phosphate esters, or aryl phosphate esters in solution. Additives can include iron, chromium, and/or other transition metals. Alternative or additional additives can include magnesium compounds to facilitate growth of films on substrates that do not contain magnesium.

Formulation of a precursor begins with mixing of the ingredients into a high-vapor-pressure solvent to form a homogeneous solution. Then the solvent is extracted from the solution by evaporation — aided, if necessary, by vacuum and/or slight heating. The solvent is deemed to be completely extracted when the viscosity of the remaining solution closely resembles the viscosity of the phosphate ester or aryl phosphate ester. In addition, satisfactory removal of the solvent can be verified by means of a differential scanning calorimetry essay: the absence of endothermic processes for temperatures below 150 °C would indicate that the residual solvent has been eliminated from the solution beyond a detectable dilution level.

This work was done by Wilfredo Morales of **Glenn Research Center** *and Jorge E. Gatica and John T. Reye of Cleveland State University. Further information is contained in a TSP (see page 1)..*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17537-1.

Making Macroscopic Assemblies of Aligned Carbon Nanotubes

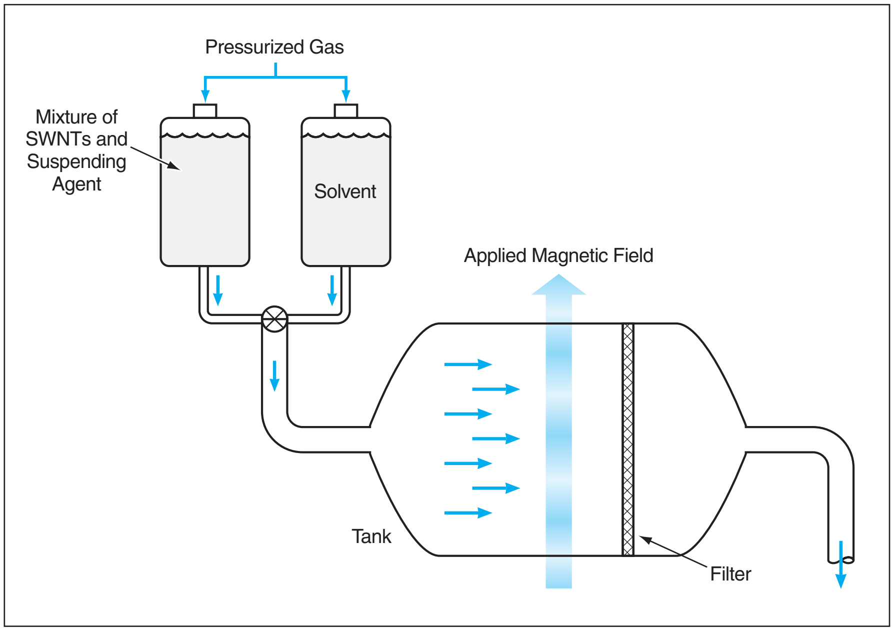
Nanotubes are aligned and manipulated with the help of magnetic and/or electric fields.

Lyndon B. Johnson Space Center, Houston, Texas

A method of aligning and assembling single-wall carbon nanotubes (SWNTs) to fabricate macroscopic structures has been invented. The method entails suspending SWNTs in a fluid, orienting the SWNTs by use of a magnetic and/or electric field, and then removing the aligned SWNTs from suspension in such a way as to assemble them while maintaining the alignment.

SWNTs are essentially tubular extensions of fullerene molecules. It is desirable to assemble aligned SWNTs into macroscopic structures because the common alignment of the SWNTs in such a structure makes it possible to exploit, on a macroscopic scale, the unique mechanical, chemical, and electrical properties that individual oriented SWNTs exhibit at the molecular level. Because of their small size and high electrical conductivity, carbon nanotubes, and especially SWNTs, are useful for making electrical connectors in integrated circuits. Carbon nanotubes can be used as antennas at optical frequencies, and as probes in scanning tunneling microscopes, atomic-force microscopes, and the like. Carbon nanotubes can be used with or instead of carbon black in tires. Carbon nanotubes are useful as supports for catalysts. Ropes of SWNTs are metallic and, as such, are potentially useful in some applications in which electrical conductors are needed — for example, they could be used as additives in formulating electrically conductive paints. Finally, macroscopic assemblies of aligned SWNTs can serve as templates for the growth of more and larger structures of the same type.

The great variety of tubular fullerene molecules and of the structures that



A **Solution Containing Suspended** SWNTs is made to flow through a magnetic field and a filter. The magnetic field orients the SWNTs predominantly parallel with each other in the plane of the filter. Hence, the SWNTs become deposited on the filter in alignment with each other.