Purification and Processing of Nanomaterials at the NASA-Johnson Space Center

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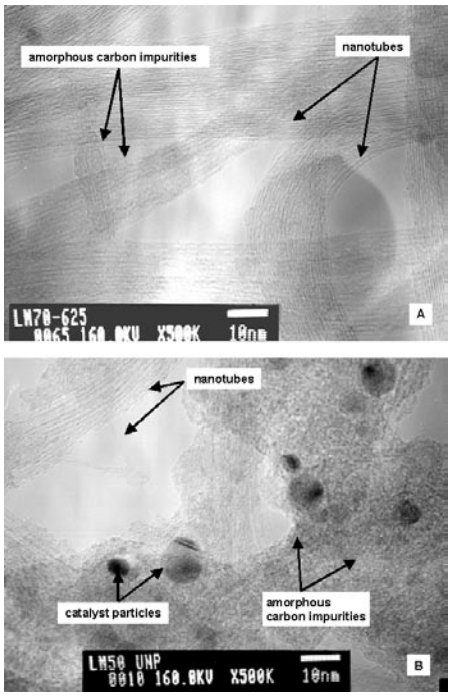
The Nanomaterials Purification and Processing team at NASA-JSC provides support to nanotube applications efforts by purifying raw nanotubes and processing this material into useful morphologies. The as-produced (raw) single-wall carbon nanotube (SWCNT) material contains a variety of impurities including spherical fullerenes, amorphous carbon, other forms of non-nanotube carbon, and catalyst metal particles. Each source of raw nanotube material is a unique challenge for purification.



Transmission electron microscope images of well-purified (A) and unpurified (B) SWCNT. Scale bars are 10 nanometers.

In 2000, the NASA-JSC purification team published a comprehensive NASA-contractor report on the effect of different purification steps. Further research is in progress to improve the efficiency of the purification. In the year 2005, the applicability of "soft-baking" (oxidation of impurities by hot steam) as a first step for purification of SWCNTs was studied to improve the purity of the SWCNT material.

For a variety of applications, it may be necessary to add functional groups (alkyls, amines, hydroxyl groups, etc.) to SWCNTs to improve or modify the physical and chemical properties of the nanotube material. Functional groups may be attached with covalent or non-covalent bonds. Stabilization with surfactants (soaps) is commonly used to improve nanotube solubility in water. A number of surfactants work well with nanotubes. The π-π bonding complexes are used to improve nanotube solubility and dispersion in organic solvents and polymers. Covalent functionalization of nanotubes is done by acid reflux, fluorination, birch chemistry, diazonium salt chemistry, etc. Some applications (fuel cell electrodes, supercapacitor electrodes, etc.) require control of porosity of nanotubes. Processing techniques to control porosity of carbon nanotubes are under investigation.

The following processing techniques have been studied: (1) Techniques to improve the surface area and porosity of SWCNTs for electrode applications, including modifications of purification procedure, and of drying procedure and freeze-drying (technique used for space food preparation); (2) Techniques to improve the solubility of SWCNTs in water by changing the acidity of the solution and by boiling SWCNTs in water; and (3) Modification of nanotube surface, including coating with silica (to create nanoscale silica fibers for thermal protection systems) and chemical modification with aniline and polymeric amines (for applications in the life support systems).