Safer Carbon Nanotubes through Targeted Removal of Bioavailable Metal

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In 2008, the research groups of Professor Robert Hurt and Agnes Kane at Brown University demonstrated a method to reduce the health risks associated with carbon nanotubes. Almost all nanotubes contain metal nanoparticles that are residues of the growth catalyst, and such ultrafine metal particles are known to pose health risks upon inhaltion. These metal nanoparticles appear to be trapped inside of carbon shells (see left side of Figure); nevertheless some nanotube metal has been reported to be released as soluble, bioactive forms in the body, where it has the potential to cause toxicity. Many nanotube samples are now "purified," but even these purified samples typically contain some of this active "bioavailable" metal.

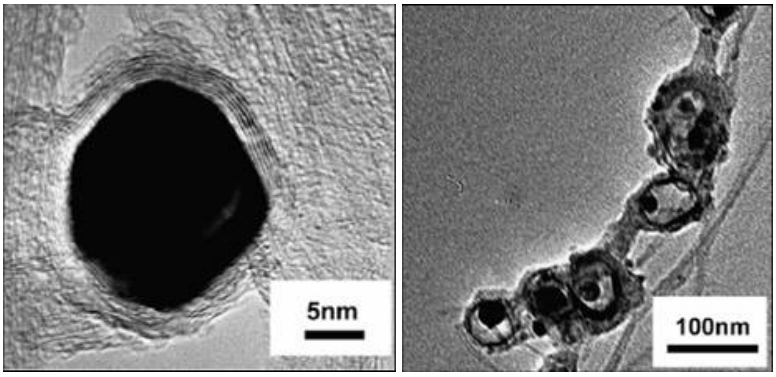

Figure. *Caption*

The work by the Hurt/Kane groups focused on identifying the origin of the bioavailable metal in nanotubes and developing improved purification methods that specifically target that portion of the metal. The 2008 study published in the materials journal *Carbon* (Liu et al. 2008), found two sources of "bioavailable" metal in nanotubes: (1) nanoparticles found inside defective carbon shells that are only slowly dissolved by acid washing (see right side of Figure) and (2) metal salts that redeposit on nanotube surface functional groups during processing. The authors also demonstrated new protocols for acid washing that reliably remove the bioactive part of the metal catalyst.

These results will be useful in guiding carbon nanotube manufacturers and users toward more effective and reliable purification processes that will reduce nanotube toxicity. While these new protocols do not remove all the potential health concerns associated with carbon nanotubes (some suspected toxicity mechanisms do not require metals), they do provide an important first step in the development of safe nanotubes through intelligent "green" design and processing.

Reference/Publication

Liu, Xinyuan, Lin Guo, Daniel Morris, Agnes B. Kane, Robert H. Hurt. 2008. Targeted removal of bioavailable metal as a detoxification strategy for carbon nanotubes. *Carbon* 46 489-500.