Lead Inventor: Stanislaus S. Wong, Ph.D., Associate Professor, Department of Chemistry

Title: Methods for Controlling Silica Deposition onto Carbon Nanotube Surfaces

Background: The remarkable structure-dependent optical, electronic and mechanical properties of single-walled carbon nanotubes (SWNTs) have attracted a lot of attention over the last decade due to their potential in applications as varied as molecular electronics, sensor technology and high performance composites. In general, the synthesis of carbon nanotube-insulator heterostructures is important for the use of carbon nanotubes in applications ranging from field effect transistor (FET) devices to molecular circuits and switches. Specifically, carbon nanotube-silica heterostructure composites are particularly intriguing because of the well-known insulating properties of silica. A protective layer of silica applied to the surface of the nanotube will limit the perturbation of the desirable mechanical and electronic properties of the nanotube while simultaneously providing for a means to functionalize these nanoscale species. Furthermore, a thin, transparent silica coating on the carbon nanotube’s surface will enable its utilization in applications associated with biomedical optics.

Technology Description: The technology developed by Dr. Wong and his associates controls the rate of non-covalent silica deposition onto the carbon nanotubes through electrochemical solution deposition techniques. The methodology has several advantages over other previously reported techniques in that the thickness of the resultant silica film can be controlled rather easily by rationally varying reaction parameters such as potential and current, as well as reaction time and sol concentration. This level of control allows for these functionalized tubes to be used in a variety of electronics and optics applications.

Applications: (a) Functionalization can enable fabrication of insulator-coated SWNTs which find use as building blocks in nanotube devices such as FETs. (b) Coatings of dielectric materials can be placed on SWNT ends and sidewalls through a well-defined, relatively mild molecular reaction, which is structurally non-destructive to the nanotube itself. The electronic character of the tubes is preserved. (c) Ability to biocompatibilize carbon nanotubes through the silica coating, thereby rendering these materials useful for a wide range of biological applications. (d) Generation of carbon nanotubes with high resistance to oxidation, and (e) Generalization of this technique to other materials, such as metal oxides.

Advantages: This electrochemical methodology has several advantages. First, the silica appears to be coated on the nanotubes in a noncovalent and therefore nondestructive fashion. Secondly, the procedure is fairly mild and environmentally friendly in that these experiments require a minimum amount of reactants and conditions that are neither harshly acidic nor basic conditions. Thirdly, the actual reaction time needed for electrodeposition was only about 5 to 10 min, as compared with the much longer reaction times associated with other methods. Moreover, all of these experiments were carried out at room temperature under ambient conditions. Furthermore, this is also the first controllable methodology proposed aimed at the fine tuning of the silica film thickness on carbon nanotube surfaces through a solution phase methodology involving a rational and systematic variation of reaction parameters.

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For additional information please contact: Ms. Donna Tumminello
Assistant Director
dtumminello@notes.cc.sunysb.edu
Phone: 631-632-4163