Chemist's technique enables creation of novel carbon nanoparticles

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Using a technique pioneered by Washington University in St. Louis chemist Karen Wooley, Ph.D., scientists have developed a **novel way to make discrete carbon nanoparticles for electrical components** used in industry and research.

The method uses polyacrylonitrile (PAN) as a nanoparticle precursor and is relatively low cost, simple and potentially scalable to commercial production levels. It provides significant advantages over existing technologies to make well-defined nanostructured carbons. Using the method, PAN copolymers serving as carbon precursors can be deposited as thin films on surfaces (for example, silicon wafers), where they can be patterned and further processed using techniques currently employed to fabricate microelectronic devices. Such a seamless manufacturing process is important to generate integrated devices and would be difficult to achieve with other methods currently used to synthesize nanostructured carbons, said Tomasz Kowalewski, Ph.D., assistant professor of chemistry at the Mellon College of Science and principal investigator on this research.

The research was presented March 28, 2004, at the 227th annual meeting of the American Chemical Society in Anaheim, Calif. The research findings have been accepted for publication in Angewandte Chemie, International Edition. The work was funded by the National Science Foundation.

The new approach is based on a method the Carnegie Mellon group previously developed to form nanostructured carbons by using block copolymers in which PAN is linked to other polymers with which it normally does not mix. In the current method, PAN, a water-hating compound, is copolymerized with polyacrylic acid, a water-loving polymer. In water-containing solutions, PAN-polyacrylic acid copolymers self assemble into nanoscale droplets, or micelles. Each micelle has a water-insoluble PAN core and a water-soluble polyacrylic acid outer coat that forms an outer shell.

The linchpin to make carbon nanoparticles from micelles is a shell-crosslinking technique that Wooley developed with Ph.D. student K. Bruce Thurmond II — now a research scientist at Access Pharmaceuticals, Dallas, Tex. — in the late 1990s at Washington University. Whereas polymer micelles are dynamic assemblies that can be reorganized or destroyed, the shell crosslinking technique allowed the Carnegie Mellon researchers to contain the PAN within the polyacrylic acid to maintain discrete nano-objects during manipulation of the materials. The scientists then deposited thin and ultra-thin films of these nanoparticles on various substrates. The Carnegie Mellon team heated the nanoparticles to high temperatures in a process called pyrolysis, decomposing the polyacrylic acid shell scaffolding and converting the chemically stabilized PAN domains into arrays of discrete carbon nanostructures.

"The preparation, manipulation and study of these highly interesting, discrete carbon nanoparticles were facilitated by an interdisciplinary collaboration that has involved the open sharing of knowledge, ideas, resources and researchers between several laboratories located at Washington University and Carnegie Mellon University," said Wooley. "This kind of cross-institutional teamwork provides for enhanced student experiences and allows for research accomplishments that would not ordinarily be possible, activities which have been supported in large part by the National Science Foundation."

"This work really illustrates a particularly attractive strategy in the evolution of nanotechnology," said Kowalewski, principal investigator on this research and a postdoctoral researcher at Washington University in the late 1990s, and long-time collaborator with Wooley. "Our well-defined carbon nanoparticles should find a wide range of applications, especially in energy storage/conversion devices and in display technologies."

The Carnegie Mellon group is currently working on using carbon nanoparticles as active materials in field emitter arrays for flat panel screen displays. This technology to produce carbon nanostructures also could be adapted to produce solar panels that convert sunlight into electrical energy. Other applications include the development of carbon-based nanosensors or high-surface area electrodes for use in biotechnology or medicine.

The original press release can be found here news-info.wustl.edu/news/

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