The First World of Coal Ash Meeting Held in Lexington

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As I write this it is May 3, 2005. This is my third time to exhibit at a scientific meeting since April 11th. Looking around Coal Prep, an annual conference and exhibit in Lexington, KY. I see a large, well-organized trade show, with about 200 exhibit booths and almost 2,000 attendees. Two weeks ago I exhibited at The 31st International Technical Conference on Coal Utilization & Fuel Systems (better known as the Clearwater Conference), a much more technical meeting. There were about a dozen exhibitors there, most of whom represented associations, rather than vendors.

Before either of these meetings occurred, there was a new meeting called The World of Coal Ash or WOCA. I’m wondering how to characterize WOCA and what made it special. First, along with a group of co-conspirators, I worked very hard at organizing WOCA. Its predecessors were two separate former meetings: the University of Kentucky Center for Applied Energy Research’s International Ash Utilization Symposia (1995-2003) and the American Coal Ash Association’s meetings (which began in 1967). Both of these meetings worked well for many years. Each had its distinct personality.

Part II: From Conducting Polymers to Carbon Nanotubes: A Revolution of Sensors based on Architectural Diversity of the $\pi$-Conjugated Structure

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(This is the second part of a two-part series on the revolution in materials science due to the discovery of nanoscale technology. To read the first installment, see Energeia v. 16 (2), http://www.caer.uky.edu/energeia/PDF/vol16_21.pdf)

Sensor chips (or sensor arrays) consist of many different sensors on a single chip and enable us to identify complex mixture systems even without separation. Self-assembling could facilitate the development of sensor chips by adding multifunctional supramolecular structures to the existing sensing devices and systems. In collaboration with McCall and Moghaddam at CSIRO in Australia, we have developed a photochemical method to functionalize carbon nanotubes with photoreactive reagents (e.g. aziridothymidine, AZT), followed by the coupling of ssDNA chains onto the carbon nanotube through the photo-adduct and coating the nanotube sidewalls with cDNA-modified gold nanoparticles via DNA hybridization (Figure 5).

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The consensus was that the CAER’s symposium was a little bit more scientific, as is appropriate for a university-organized meeting; and the ACAA’s conference was a little more about applications, which was also appropriate for a commercially-affiliated association.

Then a few individuals had the vision to combine these two meetings.

It seems as if the melding of these two seemingly disparate organizations would be difficult. It wasn’t. Everyone wanted this meeting to work.

Therefore, small philosophical differences were put aside. A common goal was worked toward. This show of unity resulted in an unqualified success. By the numbers, the two previous meetings claimed no more than 300 or so participants each. WOCA’s attendance topped out at 560. This included attendees from 22 countries. About 200 presentations were made, including 32 posters. A half day was added to accommodate presentations. Forty exhibitors attended and 17 sponsors thought it worthwhile to support the event.

The technical program committee strove for a balance. While trying to avoid 25-minute advertisements for products or processes disguised as talks, too many presentations on scientific minutiae were frowned upon as well. Hitting that balance of interest, relevance, and appropriateness to the audience, while perhaps not always achieved, was the goal.

It is incumbent upon us as a university to educate. Education takes many forms. One of those forms is educational outreach – not in a classroom, but in our scientific fields of endeavor.
The ash program at CAER, headed by Dr. Tom Robl, is a particularly strong one. You can’t put a dollar value on the educational awareness that this meeting provided for our audience and ash researchers. Part of the ACAA’s mission is to advance the use of coal combustion products. The utilization of ash is exactly what this meeting was about.

As a longtime meeting planner, I have noticed that at the end of the meeting, no matter how outstanding the technical talks, what folks tend to remember is whether or not they had a good time. Did they get an opportunity to network? Did they enjoy the food and receptions? Were there problems with the audio visuals that delayed talks? Were logistics clear? Was the registration staff friendly and accommodating? Although slightly prejudiced, I think that the planners worked hard on all aspects of the meeting and we have heard very few complaints so far.

If you are part of the ash community, but didn’t attend the recent WOCA meeting, go to http://www.worldofcoalash.org/ to see details of the meeting.

It was a pleasure to be part of this great conference. Now it is time to get geared up for 2007!
The locations of the DNA molecules attached onto the carbon nanotubes can be determined by a visual assay using cDNA-modified gold nanoparticles and transmission electron microscopy (TEM). Figure 5b shows gold nanoparticles positioned in close proximity to the surfaces of the nanotubes; the sample was prepared by binding cDNA-attached gold nanoparticles of a 16-nm-diameter to the ssDNA chains grafted on the nanotubes, followed by a further hybridizing of the remaining unbound cDNA on the 16 nm gold nanoparticles to their complementary DNA chains. Furthermore, we have also prepared a wide range of multi-component structures of carbon nanotubes (Figure 6) through DNA-direct self-assembling of carbon nanotubes and gold nanoparticles in a solution for multifunctional material and device applications.

On the other hand, we have recently synthesized, in collaboration with Wan’s group at the Chinese Academy of Sciences, polyaniline (PANI) nanotubes (Figure 7a) via a self-assembled C_{60}(OH)_{18}(OSO_{3}H)_{6} supramolecular template using (NH_{4})_{2}S_{2}O_{8} as an oxidant. This, together with the more recent discovery of patterned and non-patterned generation of conducting polymer micro-/nano-containers self-assembled around the surface of “soap bubbles” produced on an electrode by electrolysis of appropriate electrolyte solutions (Figure 7b), clearly indicates that supramolecular engineering has broadened the scope for developing multidimensional and multifunctional π-conjugated structures of significance for sensor and sensor chip applications.

In addition to the use of the sulfonated C_{60} supramolecular template and soap bubble template for producing conducting polymer micro-/nano-structures, we have also used the aligned carbon nanotubes as nano-electrodes for making novel conducting polymer-coated...
carbon nanotube coaxial nanowires (CP-NT) by electrochemically depositing a concentric layer of an appropriate conducting polymer uniformly onto each of the constituent aligned nanotubes (Figure 8a). To demonstrate the potential sensing applications for the CP-NT coaxial nanowires, we have immobilized glucose oxidase onto the aligned carbon nanotube substrate by electro-polymerization of pyrrole in the presence of glucose oxidase. The glucose oxidase-containing polypyrrole-carbon nanotube coaxial nanowires were used to monitor the concentration change of hydrogen peroxide (H$_2$O$_2$) generated from the glucose oxidation reaction by measuring the increase in the electro-oxidation current at the oxidative potential of H$_2$O$_2$.

20mM, which is higher than 15mM typically for the detection of blood glucose in practice. Furthermore, responses from the CP-NT glucose sensors were found to be about ten orders of magnitude higher than that of more conventional flat electrodes coated with glucose oxidase-containing polypyrrole films under the same conditions. Apart from the large surface/interface area obtained for the nanotube-supported conducting polymer layer, which is attractive for using them in sensing applications, the coaxial structure allows the nanotube framework to provide mechanical stability and efficient thermal/electrical conduction to and from the conducting polymer layer. The CP-NT nanowire sensors were also demonstrated to be highly selective for glucose with their electro-oxidation current responses being almost unchanged even in the presence of some interference species, including ascorbic acid, urea, and D-fructose. The well-defined nano-channels of the perpendicularly aligned carbon nanotubes could provide additional discrimination for the detection of single molecules in a complex environment, leading to highly sensitive and selective nanotube sensors. This is clearly an area in which future work would be of value.

These are just some examples, which show that advanced sensors and sensor arrays could be developed from conducting polymers and carbon nanotubes. The tiny size of nanotube sensors implies that they are very energy efficient and could move through the cell membrane without obvious harmful effect on the cell function. With so many transduction methods and micro-/nano-fabrication techniques already reported and more to be developed, there will be vast opportunities for developing numerous complex measurement devices with capabilities for various sophisticated analyte detection from chemical and biological sensors based on the architectural diversity of the π-conjugated structure. Continued research and development efforts in this exciting field will surely revolutionize the way in which future chemical and biomedical tests to be performed in both research and clinical diagnostic laboratories that could affect many aspects of our lives.

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