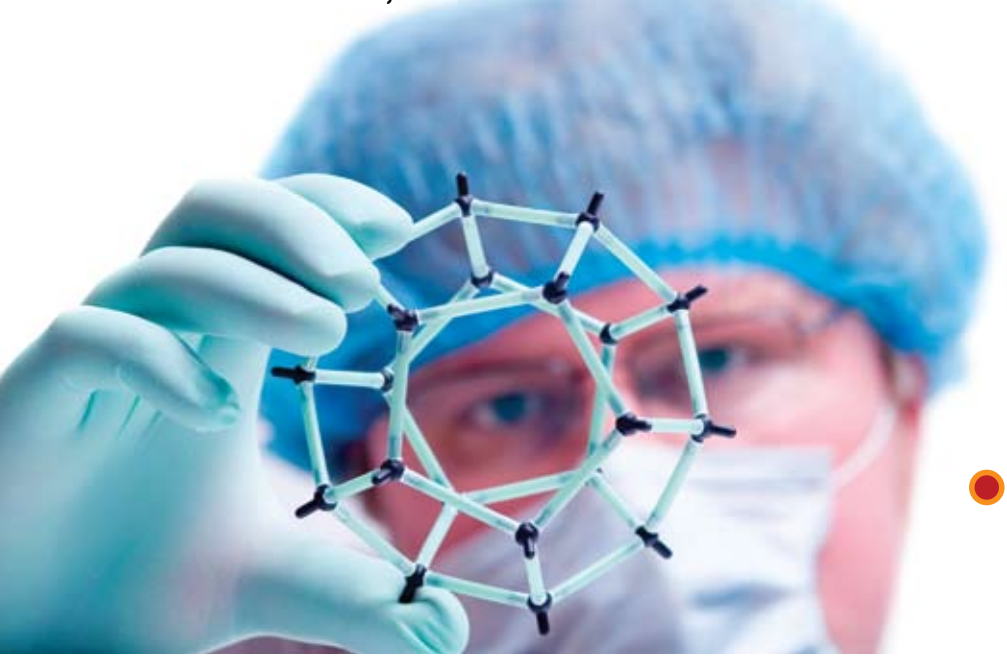
Gauging the nano risks

RESEARCHERS, INDUSTRY CAUTIOUS WHILE IDENTIFYING MEASREMENT NEEDS

Peter Wray



When you get a group of nano materials researchers and entrepreneurs together and ask them what kinds of things they'd like to be able measure, porosity, shape, dispersion, solubility, purity, detection, bio-compatibility and so on. Actually, you might end up with a list of well over 100 specific physical and chemical characteristics that are on their measurements wish list.

Get a group of nano environmental health and safety specialists together and ask them what they'd like to be able to measure, you'd also hear: structure, porosity, shape, dispersion, solubility, purity, detection, bio-compatibility, etc.

In other words, the needs of these two groups – at least at this point in the development of nano sciences – strongly overlap. And, given that a large number of the commercial applications for nano materials are for medical purposes, it's not surprising that many of their interests regarding cellular, metabolic and internal distribution measurements are identical.

That overlap of interests is the good news. The bad news is that, unfortunately, the ability of anyone to accurately and reproducably make just one measurement for just one nano material can be very difficult and expensive given the current limitations of measurement equipment.

Increasingly, it is dawning on experts and government officials that the field of nano materials for the first time has opened such a unique physical and chemical world that there is real difficulty even defining what many of these measurement terms mean when the work is being done at the sub-micron and atomic levels.

One sign of the current difficulties is that it recently took an international group of scientists from around the world over a year of meetings to agree on an appropriate definition of "nano."

The enormous challenges and barriers to grappling with nano EHS issues were openly acknowledged at a recent workshop organized by ACerS and sponsored by NIST, USMS and the National Institute of Environmental Health Sciences.

Tom Campbell, director of nanotechnology for ADA Technologies warned workshop participants that

scientists and businesses needed to think of measurements beyond application purposes. "There is another level, another set of properties that have to addressed. How are these things gong to interact in soil, air, water, media? They can change. If you introduce a nano material into the body via nano medicine, then you have to understand how this material is going to clear the body or affect the metabolic pathways or how it is distributed to organs," he advised.

"It's not just in the synthesis side," Campbell continued, "and it's not just the utility side, and the product out in the field. It's incumbent upon us to drill down toward the eventual usage, disposal and, hopefully, the recycling of the product. We have to understand the EHS impacts throughout their lifecycle."

Campbell and staff from the USMS have been surveying and analyzing all of the major public, private and NGO roadmaps on both nano materials and nano EHS studies and have developed an initial list of 104 different measurement needs, including 34 that are strongly related to nano EHS.

But, there is a vast gulf between identifying general measurement needs and actually getting the measurements done. Campbell and the USMS say that significant measurement barriers exist, particularly in the application science area, that all stakeholders must come to grips with.

According to Campbell, the barriers have little to do with cost or concern for safety. "Our preliminary analysis of the data shows that those of us in the nano field are right up against the limits of anyone's ability to get accurate and reliable measurements, at proper resolutions, and that we still lack fundamental knowledge about these materials, particularly in systems like the human body.

"Our biggest problem for both EHS concerns and innovation are the same. We simply lack the instruments, techniques and methods of accurately characterizing the behavior of complex material systems and structures. We are making progress, but we are far from where we need to be," Campbell said.

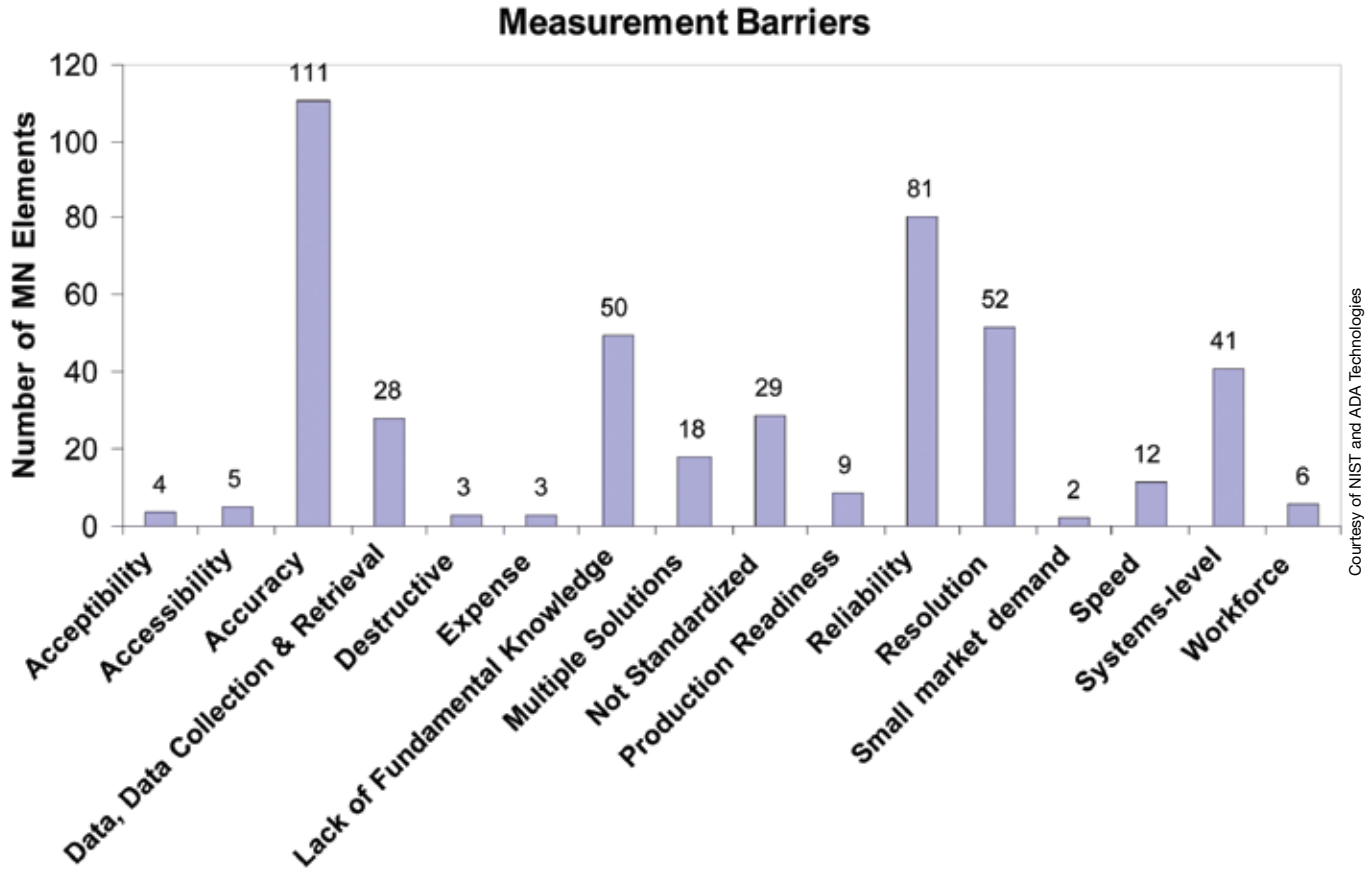
History: Help or Hindrance

It's unlikely to have a discussion about nano EHS without having the topic of asbestosis, silicosis and mesothelomia coming up. Especially in the ceramics field, the mere mention of these diseases still generates controversy – and a big question: Will this legacy be repeated with nano materials?

Despite the apparent potential for nano products to bring dramatic improvements to medicine, energy, water supplies, etc., there is general agreement among researchers, entrepreneurs and advocates for workers and the environment that real or perceived dangers could, unfortunately, sink this nascent field for decades.

This was evident by the immediate and strong reaction to a study Andrew Maynard and others published in late May 2008 in *Nature Nanotechnology* that the authors say indicate that carbon nanotubes injected into mice caused asbestos-like inflammation. (see sidebar, "Science or Scare?").

While Maynard's study has supporters and detractors, concerns about



Courtesy of NIST and ADA Technologies

nano dangers is already having at least one affect. "Instead of being a badge of innovation, increasingly I have seen businesses playing down or removing any reference to nano materials in their products. They believe that dangers of being linked to nano problems outweigh the benefits," said Campbell.

Rather than an end in itself, the ACerS workshop on EHS measurements helped the ongoing tasks by confirming three priorities:

- Develop a common, precise language and glossary for nano measurement terms
- Develop and share emerging databases on characteristics, measurement equipment and techniques
- Focus EHS studies where applied research is being conducted because it is the most active stage of nano innovation

Taking the high road

With so much still unmeasured and unknown about these materials, Alan Rae from NanoDynamics, a fuel cell and nano materials development company, urged stakeholders to understand the potential health risks and err on the side of caution.

"Businesses and research outfits, especially small ones where most of the nano product development is occurring need to carefully assess what they are doing from a health and safety point of view. Ignorance cannot and will not be a defense," advised Rae.

He said that small operations tend to have few if any staff that are familiar with or have regard for generic safety regulations. "These businesses seldom have dedicated EHS staff and, at best, are very dependent on outside advice and training. But, and this is important, the number one cardinal rule has to be: Nobody must be harmed," he urged.

He said that a laissez faire approach was unacceptable. "We might never be to the point where we can make every possible measurement on every nano material, but we must make every effort to gather and share relevant information. Regulations come from a large number of state, federal and international agencies and small businesses must be aware of and utilize this information," said Rae.

According to Rae, this also means being one step ahead of an enterprise's processes. "There is a huge and potentially dangerous transition that takes place when a material moves from the lab to large scale production by a regular workforce. This requires sharing information with the workforce, mandatory training, mandatory monitoring, personal protective equipment and preparing appropriate material safety data sheets, just to name a few."

Rae admitted that one of the problems is the overwhelming amount of general information that's emerging. "A Google search for the words nanotechnology and environment brings up more than two million hits. This is like drinking from a firehose. Stakeholders, therefore, have to make good use of the agencies and NGOs that aggregate and condense this information. (see box above)

Asked how he'd summarize his advice, Rae said, "Two things. Make EHS a priority upfront. Second, work with others in our field, and communicate with the regulatory bodies and industry associations to stay on top of changes. It is too complicated and there is too much at risk to try to do this alone. ■

Condensed sources of nano EHS information include:

- Industry Associations, local and national:
  IEEE(ewh.ieee.org/r6/san_francisco/nntc)
  Vision2020 (chemicalvision2020.org/nanomaterialsroadmap.html)
- Government agencies
  NNI (nano.gov)
  NIOSH (cdc.gov/niosh/topics/nanotech)
- NGOs:
  Woodrow Wilson Institute (nanotechproject.org/)
  Clean Production Action (cleanproduction.org)
  National Resources Defense Council (nrdc.org)
  Nanotechnology Law & Business (nanolabweb.com)

Science or Scare?

News outlets around the world recently stirred the nano pot when they ran stories about a study published May 20, 2008 in *Nature Nanotechnology* by Poland that stated that long multiwalled carbon nanotubes injected in to the abdomens of mice showed "asbestos-like pathogenicity." Reactions to the media stories and to the study, itself, have been strong and varied:

"[These findings] didn't surprise me too much given the high dose and a certain similarity of individual MWCNT fibers with asbestos, and given that elemental carbon is not soluble and very bio-persistent like asbestos … This is a "Proof of Principle" study: MWCNT under these conditions can induce effects. The question is: Will it happen in vivo following inhalation exposure? We need to know that before we come to a final judgment."
- Gunter Oberdorster, Director of the University of Rochester Ultrafine Particle Center, PI of a Multidisciplinary Research Initiative in Nanotoxicology

By [the media] pushing the correlation between asbestos and MWCNTs the lay audience will certainly consider carbon nanotubes a public hazard. Even in the case of workers involved in manufacturing the particles, the articles report that precautions have already been put into place requiring workers to wear respirators. Towards the end of media articles, reporters point out that the study did not look at how likely and/or easily carbon nanotubes become airborne or whether they become lodged in the lungs if inhaled. But this consideration of dosage and exposure is now irrelevant to the public that is concerned with consequences and implications only.
- David Burebe, author of Nano-Hype *and the NanoHype blog*

This was a well-conducted study that raises concerns about the safety of long carbon nanotubes. As the authors point out, they did not look at whether the mice exposed to long carbon nanotubes went on to develop mesothelioma, and therefore have not shown that long carbon nanotubes cause cancer … The authors also make it clear that they have not looked at whether inhaled long carbon nanotubes would cause inflammation or cancer of the mesothelium of the lungs, and if so, whether the levels in workplaces dealing with long carbon nanotubes would be high enough to cause these effects. Further research will clarify these issues.
- (U.K.) National Health Service Knowledge Service

[Q]uestions have been raised about using these research findings for risk assessment analysis in the light of study limitations such as use of model animals, artificial administration methods, and sometimes extremely high doses, which are not representative of those exposures usually present in the workplace environment. Such limitations are not unusual for pioneering scientific studies. They simply mean that at this stage of the research, gaps remain that need to be closed by further study before quantitative risk assessment can be conducted.
- Vladimir V. Murashov, Ph.D., Special Assistant for Nanotechnology to the NIOSH Director