BY RANDY WEDIN

Is Nanotechnology Safe?

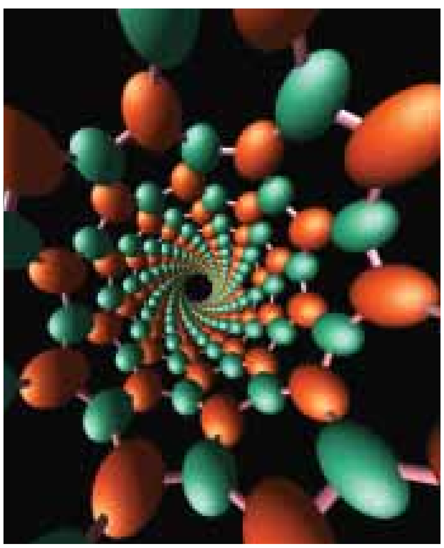
Leaders from industry, academe, and environmental groups agree on the need to understand the potential risks of nanotechnology before the small technology makes a big splash.

The chief executive officer of the world's third-largest chemical company and the president of a leading nonprofit environmental organization may seem unlikely to agree on a major public policy issue.

But these two leaders—Chad Holliday, Jr., chairman and CEO of DuPont, and Fred Krupp, president of Environmental Defense—coauthored a *Wall Street Journal* op-ed article. In "Let's Get Nanotech Right" (June 14, 2005), the authors urged improved understanding of the environmental safety and health (ESH) aspects of nanotechnology. "An early and open examination of the potential risks of a new product or technology is not just good common sense—it's good business strategy," they wrote.

In the months since then, a flurry of national and international reports, congressional hearings, and conferences has further heightened the visibility and urgency of this issue.

Why all the fuss? Why now?



VIN CRESPI, PENNSYLVANIA STATE PHYSICS

A VIEW DOWN THE MIDDLE of a boron nitride nanotube

Big Benefits

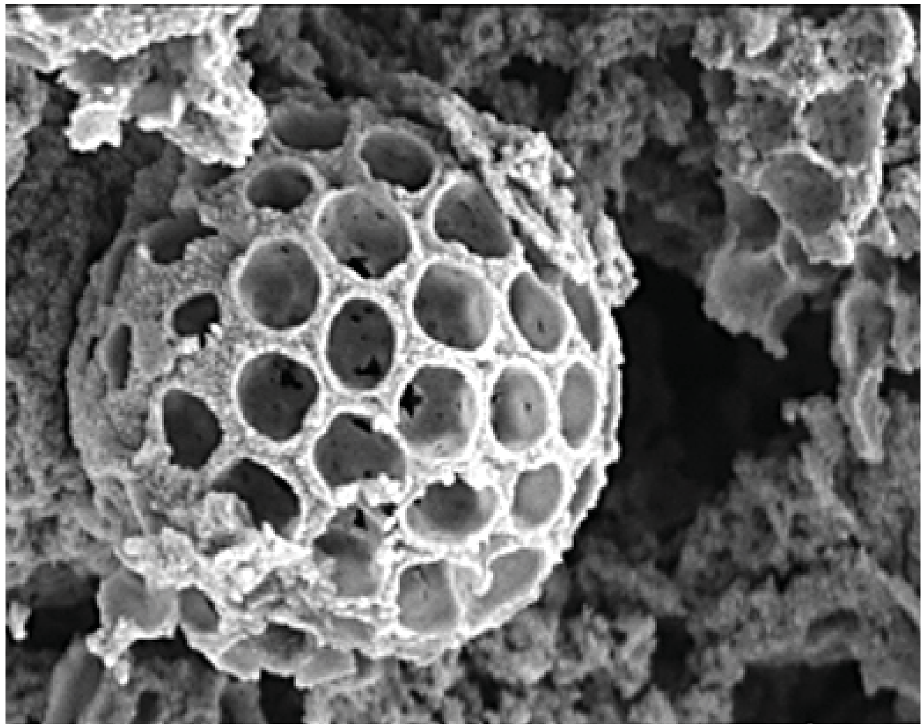
Industry, government, and media leaders have realized that nanotechnology is more than just the latest buzzword. These very small materials are about to become very big business, with a global economic impact that could reach $1 trillion annually by 2015, according to the National Nanotechnology Initiative (NNI). That interagency consortium (www.nano.gov) oversees the federal government's nanotechnology activities.

Dozens of consumer products incorporating engineered nanomaterials are already in the marketplace—from sunscreens to tennis racquets, contact lenses to car bumpers. And more are on the way.

NNI defines the "new nanotechnology" that is garnering all this interest as "the understanding and control of matter at dimensions of roughly 1–100 nanometers to produce new structures, materials, and devices." In this nanoworld where both classical and quantum effects can be important, scientists and engineers are learning to build and refine nanomaterials that may demonstrate properties not found in bulk materials.

The unconventional physical and chemical properties of a nanomaterial include different conductivity, reactivity, and optical sensitivity. They result from factors as varied as small size, chemical composition, surface structure, solubility, shape, or aggregation.

Consider one specific example: nanoparticles in sunscreen products. ZnO and TiO_2 are increasingly used to provide ultraviolet (UV) protection in cosmetic and personal care products. The new sunscreens contain engineered nanoparticles so uniformly small that they don't scatter light, leaving the end product clear instead of white. And that's a big benefit in the cosmetic industry.



SASCHA KLEIN, FRED LANGE, AND DAVID PINE, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

TITANIUM DIOXIDE MICROSPHERE 1–50 microns in diameter

However, nanotechnology is a whole subset of technologies destined, perhaps, to serve as enabling technologies across many industrial sectors. The new improvements that result may be in fields as diverse as electronics, optics, sensors, materials, environmental improvement, medical imaging, catalysis, and drug delivery.

Risks and Unintended Consequences

The unconventional physical and chemical properties of nanomaterials that promise so many benefits also raise concerns about potential risks. Mindful of past technologies with unanticipated effects (such as chlorofluorocarbons, asbestos, and DDT), leaders vow to "get things right this time."

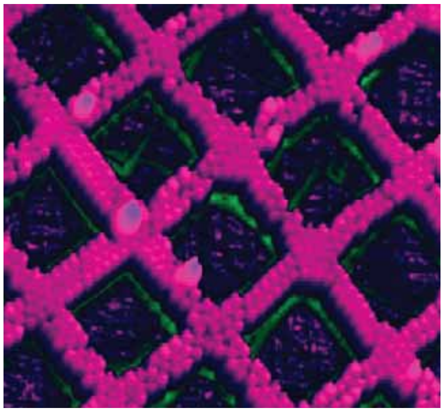
Nanotechnology carries a laundry list of potential risks. One recent review article in the February 3, 2006, edition of *Science* cited a dozen potential toxic effects of nanomaterials. They include the generation of reactive oxygen species (ROS), protein denaturation, mitochondrial perturbation, and uptake by nerve tissue.

With such a broad range of concerns, how do scientists, industry leaders, and government regulators plan to tackle the issue?

Terry Medley, global director of corporate regulatory affairs for DuPont, put the challenge this way: "One of the pivotal questions is this: Based upon what we know about the bulk material, what of that knowledge can be appropriately extrapolated to nanomaterials? ESH research should bring together baseline data which will allow you to make valid assessments when you're looking at different materials."

The NNI–Chemical Industry Consultative Board for Advancing Nanotechnology (NNI–ChI CBAN) is an industry-related group helping to outline such a strategy. Their priorities for ESH research include the development of testing strategies, metrics for particle toxicity, and methodologies for exposure monitoring (please see www.chemicalvision2020.org/nanotechnology.html for details).

As leaders from industry and academe continue to define and prioritize ESH research needs, they're also pushing for increased funding. The federal budget for nanotech research has risen from $464 million in 2001 to $1.301 billion in 2006. Holliday and Krupp contended that a much larger portion of that total budget—10% instead of the current 4%—should be allocated for ESH research.



GILBERT WALKER

POLYSTYRENE NANOPARTICLES dynamically deposited into Poly (dimethylsiloxane) grooves.

A Nanoparticle in a Haystack

With ESH research expanding rapidly, scientists, regulators, and consumers will need help finding relevant information quickly and easily. To address this need, the CBAN group fostered the creation of a free, searchable database of ESH literature and data. That database is now up and running under the sponsorship of the International Council on Nanotechnology (ICON), a multiple-stakeholder group administered by Rice University and its Center for Biological and Environmental Nanotechnology (CBEN).

The ICON EHS database (http://icon.rice.edu/research.cfm) currently contains about 1,200 research papers from peer-reviewed scientific journals. "It's a very powerful way to search for just what you're looking for," said CBEN's Kristin Kulinowski.

Kulinowski added that ICON plans to expand the database project, making it more helpful to a wider audience. "Right now, you just get a list of papers, which in itself is very useful for researchers and government officials," she said. "The next step is to put some context on that and say, 'Based on this literature database, here's what we can say about carbon nanotube pulmonary toxicity or about whether quantum dots translocate through the skin.'"

Looking Ahead, Thinking Small

Many forces over the next decade will determine nanotechnology's path. Holliday and Krupp put it well: "With the right mix of voluntary corporate leadership, coordinated research, and informed regulation, we can reap the benefits of this promising technology while reducing the likelihood of unintended consequences."

DuPont's Medley emphasized that industrial chemists will play an important role in the process. "Clearly, they are stakeholders with a lot to bring to the discussion, especially their expertise in the areas in which they work. Their engagement in this dialogue would be very useful."

So, fellow chemists, it's time to start thinking small.

Randy Wedin, Ph.D. (ACS '77), writes from Wayzata, MN. He launched a freelance writing business, Wedin Communications, in 1992. Before that, he spent a decade "inside the Beltway," working in Washington, DC, for the ACS and as a Congressional Science Fellow.