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Is Nano a No-No? Nanotechnology Advances into Buildings

An **Executive Summary** is available for this article.

It's revolutionary, it's the next big thing, and it's going to change everything. The media and industry representatives have described nanotechnology with so much excitement in the last decade, and at such a growing pace, that to illustrate the trend one investment firm has measured the explosion of this coverage with what it calls a nanotechnology hype index.

Using an "ink" that includes nanoparticles, materials the size of a billionth of a meter, Nanosolar "prints" thin-film solar photovoltaic cells on a foil substrate. The particles self-assemble into a semiconductor that drives electricity production.

Nanotechnology deals with materials at the level of 1 to 100 nanometers, with a nanometer (nm) being a billionth of a meter. Something so small is virtually unimaginable, so scientists have bent over backwards to try to put it in perspective. A man's beard grows a few nanometers in the time it takes him to raise a razor to his face Each of those hairs is 80,000 nanometers thick. The ratio of a meter to a nanometer is the same as that of the Earth to a marble.

The smallest things visible to the naked human eye are 10,000 nanometers.

Industry proponents say that this small technology will have a giant effect on green building, both doing old things better—yielding better performance from insulation, lower costs for photovoltaics, and greater strength from reduced structural masses—and creating products that haven't been imagined before—from self-cleaning roads and fabrics to electricity-generating coatings and more efficient batteries. Some researchers have also worried that nanotechnology could damage our health and environment in new ways, like turning previously nontoxic materials into toxic ones and putting undetectable, virtually uncontrollable pollutants into soil and groundwater.

At the same time, market consumption of nanomaterials is accelerating. According to the Freedonia Group, a market-research firm, there was $1 billion in worldwide demand for nanomaterials in 2006, most of it in electronics but 3% of it in construction. Freedonia says demand will grow to $4.2 billion by 2011 and $100 billion by 2025. By then, healthcare will be the biggest sector, with 50% of the market, predicts Freedonia, but construction will claim 7%, or $7 billion per year.

This article separates hype from reality while looking at a few areas where nanotechnology—or simply "nanotech"—could realistically advance environmental building goals. It also looks at health and environmental concerns of all kinds and what manufacturers and regulators are doing about them.

What's New About Nanotech?

Any material can be measured down to the nanoscale, and everything is composed of molecules and atoms that are measured in nanometers and smaller. Materials have always benefited from strength and other properties derived from these features. But until scientists were able to view matter at the nanoscale, with electron and scanning-probe microscopy, it was impossible to effectively manipulate materials at that level, view the results of experiments, and measure their properties. These optical tools, along with tools for working with matter at the nanoscale, such as electron-beam lithography, were developed in the 1980s and 1990s.

Seeing at the nanoscale

EBN shares Brattleboro, Vermont, with the headquarters of Cheap Tubes, a major supplier of carbon nanotubes. The company buys the tubes from an Asian supplier and sells them to both research institutions and manufacturers. Mike Foley, the owner of Cheap Tubes, has been watching the industry since the 1990s, when buying carbon nanotubes wasn't even possible, to today, when he sells a variety of products, some for $1.50 per gram. Foley buys large bags of nanotubes and repackages them in smaller quantities and in alcohol emulsions.

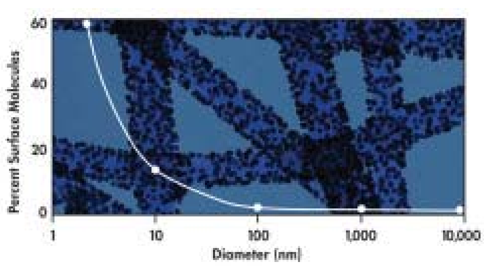
To the human eye, the tubes look like a fine black powder. Viewed through a microscope, however, it's apparent that the tubes are hollow fibers that can be over a million times as long as they are thick. Their structure gives them a strength-to-weight ratio among the highest in commercially available materials, and nanotubes can be blended with polymers to add strength to anything from car tires to golf clubs. They are also good conductors, and they are used at a much finer level in electronics.

Nanotubes aren't a new substance. According to recent research, Damascus swords contain carbon nanotubes, which might contribute to the legendary sharpness and strength of the medieval steel. Foley says all a person needs to make carbon nanotubes is a flame, a gas like methane, and a catalyst metal like nickel. However, nanotubes made in this way, and those made incidentally through combustion, are generally of low and uneven quality.

Unique properties

Nanotechnology is defined by the size at which it operates, but size matters because of unique properties that emerge at the nanoscale. For example, visible light has wavelengths of a few hundred nanometers, which contributes to the unusual behavior that light displays with nanoscale particles, or nanoparticles, compared with larger particles. Gold normally appears yellow, but nanoparticles of gold in emulsion produce a bright red color, an effect that has been used in stained glass since medieval times. Similarly, nanoparticles of zinc oxide don't scatter light, as larger particles do, making them appear transparent, and thus are more attractive than conventional zinc oxide as an ingredient for sunscreens.

Nanoparticles Provide High Surface-Area-to-Mass



As a large particle is divided into smaller and smaller pieces, the proportion of its surface area to its mass, shown here as the percentage of the particle's molecules that are on its surface, increases. This happens at an exponential rate at 100 nanometers and less. The image shows nanoparticles of the GreenShield textile finish, bonded to textile

Another property that changes at the nanoscale is the surface-area-to-mass ratio of materials, which is simply a function of geometry. The total surface area of a golf ball is only a few square inches. But divide that golf ball into millions of nanoparticles, and while its weight doesn't change, its total surface area increases to the size of a football field. Since the magnitude of many chemical reactions is limited by the available surface area of the chemicals involved, nanotechnology can make more efficient use of chemicals. That can have fairly predictable effects as well as explosive ones—nanoparticles of aluminum, which is inert in normal sizes, are explosive.

Working at the nanoscale

Controlled production of nanoparticles and the ability to shape materials at the nanoscale have opened up horizons that were hitherto unimagined. Engineer K. Eric Drexler, Ph.D., is widely credited with defining nanotechnology as a science of mini-ature machines, a captivating vision that helped bring nanotechnology into popular consciousness when he articulated it in 1986. The concept has fallen out of favor, however, as inefficient and impractical.

fibers.

Fortunately, the nightmare scenario associated with that dream—that self-powered, self-replicating "nanobots" could eat through everything on the planet, turning it into a lifeless "gray goo"—has been similarly debunked.

Instead of trying to create nanoscale machines, most nanotechnology in commercial use today simply uses the benefits of nanoparticles. For example, "nanosilver" has become a common antimicrobial treatment in everything from bandages to washing machines. Silver is antimicrobial in larger particles, but using nanoparticles makes more efficient use of this expensive metal.

In some cases, products are engineered from carefully chosen nanoparticles, manipulated through chemical and physical processes to create molecular structures with specific properties. The GreenShield textile finish from G3 Technology Innovations, for instance, is based on nanoparticles of silica. Suresh Sunderrajan, Ph.D., told *EBN* that he and other scientists at G3 bond molecules, such as fluorocarbons, to the silica to achieve desired properties, such as water-repellency. In addition to the usual product testing, they used transmission-electron microscopy during development to see if the resulting nanoparticles were structured properly.

Nanotech in Building Materials

Although nanomaterials have become more affordable in recent years, their high cost relative to conventional materials means that they are still more likely to make it inside buildings through consumer products and personal-care items than through high-volume building materials. DuPont recently launched its MetaFuse line of nanocomposites, which consists of molded plastic parts coated with a thin layer of metal, engineered at the nanoscale for strength and hardness. DuPont is targeting products like cell phone housings and golf club shafts—products in which small reductions in weight and volume can offset the increased cost of the technology and earn a premium price. The day when this technology slashes the consumption of structural steel in high-rises has not yet been contemplated. Nonetheless, the "nano" tag is showing up more often in building products.

Surfaces and coatings

A number of companies, including coatings manufacturers, are using nanotechnology to add special characteristics to product surfaces. These enhancements run the gamut from stain-resistance and color durability to self-cleaning ability, improved hardness and scratch-resistance, corrosion-resistance, UV-resistance, better thermal performance, and improved waterproofing.

Nansulate HomeProtect is an insulating coating that was engineered using nanotechnology, although it doesn't contain nanoparticles.

EBN One product already on the market is the TX Active line of concrete products from Essroc (see *EBN* Vol. 16, No. 5). TX Active uses the photocatalytic properties of titanium dioxide (TiO2). The molecules release an electrical charge upon absorbing sunlight, forming reactive radicals that oxidize nearby compounds, resisting dirt buildup. The use of TiO2 nanoparticles increases their distribution and effectiveness in the product. One of Essroc's products is also formulated to remove pollution from the surrounding air.

GreenShield is an example of how nanotechnology could bring both environmental and performance benefits to textile finishes. Like other water-repellent textile finishes, the product uses fluorocarbons, a group of chemicals associated with numerous environmental and health risks. However, G3, the developer of the product, used nanotechnology to create a precise formula that uses the active ingredients sparingly, and the increased surface area of the nanoparticles makes them more effective. But, the same properties that make the fluorocarbon nanoparticles more effective could make them more toxic.

Nanotechnology also has the potential to bring antimicrobial properties to surfaces. In research published in 2007, a team at Yale University found that carbon nanotubes were effective at killing *E. coli* bacteria. However, nanotubes can also be toxic to human cells. If nanotubes ever enter coatings as antimicrobials, therefore, we will have to reckon with the same problem plaguing all pesticides, that their toxicity is seldom limited to the target organism (see *EBN* Vol. 16, No. 8 for more on antimicrobials).

Thermal performance

Properties affecting thermal performance, such as conduction, reflectance, and emissivity, can be traced to the molecular level of materials. By tweaking these molecular properties, manufacturers have been able to significantly improve the thermal performance of materials, offering potential energy-efficiency benefits to buildings. Aerogels—very lightweight solids made from silica and carbon—are a high-performing thermal product benefiting from nanotechnology. Nanogel, made by Cabot Corporation, has been used in building materials for several years, including in translucent (but not transparent) glazings that have high insulation values compared with conventional glazings (see Vol. 11, No. 7).

NanoPore insulation, shown on the right in its vacuum packaging, provides insulation of R-40 per inch with a material containing 30–50 nanometer pores, ideal for preventing conduction of heat. The insulation provides the same R-value as the thickness of fiberglass, expanded polystyrene, and polyisocyanurate foam shown, respectively.

Another aerogel product has more recently come to the market: NanoPore Thermal Insulation from NanoPore, Inc. Like Nanogel, NanoPore is an aerogel that is extremely lightweight. NanoPore was engineered so that the pores between molecules are 30 to 50 nanometers wide, ideally suited to reducing thermal conduction. The pores are so small, according to NanoPore, they can generally only contain a single gas molecule, thus preventing molecules from colliding with each other and conducting heat. Scientists achieved that structure by mixing carbon and silica nanoparticles to an ideal ratio and using high-powered microscopes to view their results. NanoPore also goes one step further than Nanogel by packing sheets of the product under a low-pressure vacuum, much like how many foods are packaged. By virtually eliminating conductivity, the product has an insulation value of R-40 per inch, according to the company's president, Doug Smith. NanoPore recently moved from applications like high-performance cars to consumer items like refrigerators and finally into windows (see *EBN* Vol. 16, No. 10) and buildings, especially commercial retrofits where the product's price premium is offset by space savings.

Photovoltaics

Nanotechnology is ushering in what Roby Stancel, director of products at Nanosolar, calls the third generation of solar photovoltaic (PV) technology, with high performance at lower costs. The first generation, as Stancel describes it, was PV panels made from silicon wafers, which are inherently expensive because of the amount of silicon used. In the second generation, manufacturers coat a substrate with a very thin layer of silicon through a vacuum sputter-coat process. According to Stancel, "The initial promise that this would be cheaper didn't really work out." Effective coating is hard to pull off, and the silicon tends to deposit not just on the substrate but also throughout the chamber in which it is processed, creating waste.

Nanosolar offers a thin-film technology in which only a small amount of a semiconductor medium is "printed" onto a foil substrate. According to Stancel, the founders of Nanosolar looked for the cheapest way to cover a surface. "Painting is really cheap and wallpaper is really cheap," he said. "So let's paint something on a substrate that can be used as a wallpaper." The company created a process in which nanoparticles in an emulsion are deposited like ink onto foil in layers a few nanometers thick. Once deposited, they bond with each other and are baked, or *sintered*, to created a copper-indium-gallium-selenide semiconductor capable of generating electricity in sunlight. This technology is not as efficient as silicon wafers in terms of converting sunlight to energy, but it is relatively reliable and expected to be much cheaper—at least once supply catches up with demand. The company recently started production in San Jose, California, and its product is already spoken for through 2009.

Structural materials

With the strength and lightness offered by materials like carbon nanotubes, structural materials would seem to offer a natural fit for nanotechnology in buildings. So far, however, improvement of major building materials like steel, wood, and concrete is only in the research phase.

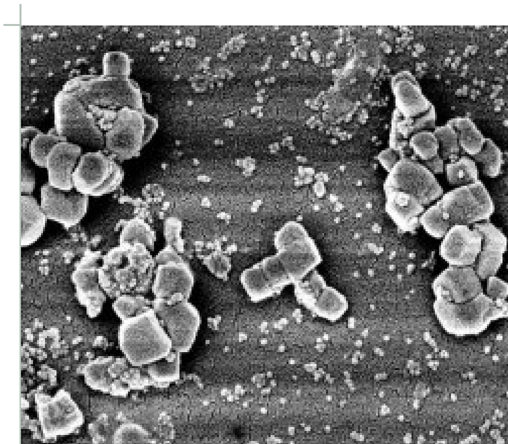
In 2006, the U.S. Department of Agriculture launched a nanotechnology research agenda for the forest products industry that focuses on investigating the properties of wood at the nanoscale in the hopes of developing advanced nanomaterials. Wood densification, chemical modification, or impregnation by resins could improve wood hardness, wear-resistance, and decay-resistance.

A group including nonprofit associations, corporations, government agencies, and universities has outlined a nanotechnology research agenda for cement and concrete for the next two decades. So far, practical applications have not emerged, but goals include improving mechanical and shrinkage properties, reducing energy consumption during cement production, developing self-powered sensors to monitor the performance of installations, developing innovative concrete materials, and better modeling the properties of concrete.

Health and Environmental Risks

Although the most shocking environmental-risk scenarios for nanotechnology, like “gray goo,” have not been supported by science, less flashy but more probable risks remain, including worker-exposure hazards, pollution from environmental releases, and toxic effects of chemicals in products. Nanoparticles exist in nature (smoke contains nanoparticles, and viruses can be as small as 20 nm), but the quantities, types, and exposure potential for artificial nanoparticles are unprecedented.

Nanotechnology’s unique benefits come with unique hazards. For example, the large surface-area-to-mass ratio that makes nanoparticles more effective in chemical reactions could also increase the level of exposure to an organism. That could improve the effectiveness of medications using nanoparticles, but it could also increase toxicity. Also, because they can pass through biological barriers, nanoparticle drugs could be delivered more effectively to a specific part of the body, but nanoparticles could pose a potent threat if unwanted particles migrate through the body. Two studies published in 1990 found that synthetic 20- and 30-nm particles could move through epithelial tissue—the thin layer of cells covering organs—and cause inflammation.



This electron-microscope image shows the Greenshield texture finish with silica and flourocarbon nanoparticles bonded to fabric.

Inhalation of nanoparticles is particularly worrisome. Several studies during the last decade, including studies in rodents and humans, have shown that exposure to airborne nanoparticles can result in significant deposition of those particles in the respiratory system. Respiratory problems have followed, as well as cardiovascular ones, including coagulation and inflammation. One research team, led by Günter Oberdörster, Ph.D., found that nanoparticles inhaled by rats could travel from the respiratory tract to the liver in four hours, moving through the walls of blood vessels. Within a week, they had made it to the olfactory bulb in the brain, bypassing the blood-brain barrier.

Although studies like these have clearly established that nanoparticles can cause health problems, or at least put themselves in position to do so, generalizations are hard to come by about how serious or widespread those problems might be. Vicki Colvin, Ph.D., a nanotechnology researcher at Rice University, has concluded that “it is far too premature to complete a formal risk assessment for engineered nanomaterials—in fact, it may never be possible with such a broad class of substances.” Given the uncertainties, some groups have advocated for a moratorium on nanotechnology research and development, but that call has not been widely taken up. Other groups have argued for a precautionary approach, with a balance of research on nanotech’s benefits as well as its risks, but a precise policy is tough to formulate with so many variables and unknowns. As nano-enhanced building materials and other products enter the market, however, the known risks would seem to recommend a prudent approach to limiting exposures.

One exposure route that doesn't get a lot of attention is disposal of used products or waste from installation. According to *The New York Times* in 2003, "Many companies assume that because they are working with compounds that are deemed safe in larger sizes or because the nanomaterials are embedded in larger products, the particles will not pose environmental threats" when discarded. That approach still seems to be the norm for manufacturers that *EBN* contacted. David Rielly at Aircuity, makers of the OptiNet system, which uses carbon nanotubes to make strong, inert pipes for moving air samples, said that since the carbon nanotubes are part of a fluoropolymer matrix in which there are no isolated particles, they pose no special hazard. Nanosolar makes a similar claim about its solar panels, as does G3i with its GreenShield coating. Some companies take a more aggressive stance by using nanotech-nology's methods to develop products but not using them in consumer products. Stuart Burchill, president of Industrial Nanotech, makers of the Nansulate coating, acknowledged concerns about nanoparticles. In response, he said, "One of the initial rules we made for ourselves was that in any product we deliver, no particle is nano in scale, it's micro in scale"—an order of magnitude larger and less of a health concern.

Unfortunately, if little is known about the safety of nanotechnology manufacturing, even less is known about the safety of the inevitable disposal. Unpredictable hazards could occur from burning, biodegradation and leaching in landfills, and exposure to water. An experiment at Rice University with carbon buckyballs (geodesic sphere-like carbon molecules) illustrates the odd things that can happen. When buckyballs were suspended in water and poured through a soil medium, they sometimes clumped and were absorbed into the soil. But when they stayed dispersed, the water formed a membrane around them, helping them slide through the soil without being absorbed, suggesting that they could disperse quickly into groundwater. Researchers have also described plausible scenarios in which bacteria absorb nanoparticles, bringing them into the food chain, or where absorbent nanoparticles bond with more toxic pollutants, making those pollutants more mobile.

The nanotech industry generally lacks enough data to make fully informed risk assessments. The danger is that instead of acknowledging this lack of information, however, the industry sometimes uses it to argue that special attention to risk factors and regulation is not needed. Even worse, according to a 2005 study by Lux Research, some nanotech companies avoid addressing safety concerns "for fear they may be held legally liable in the future for any admissions of risk made now."

Regulation

The industry hasn't yet faced highly publicized health or environmental problems of the kind that might have brought significant regulation or litigation. Industry observers often mention past experiences as warnings, however. Asbestos, for example, which bears some resemblance to nanotubes, became a costly thorn in the construction industry's side well after it had been believed to be safe and entered wide use.

In this unregulated environment, many companies using nanoparticles are choosing not to mention them. A 2006 article in *Investor's Business Daily* advises companies to promote the improvements in a product from nanomaterials but not to advertise "nano" too heavily. In July 2007, *Consumer Reports* found that out of eight sunscreens it tested, all contained nanoparticles of zinc oxide or titanium dioxide, yet only one of those products disclosed its use of nanotechnology on the bottle. The relevance to consumers isn't trivial: studies show that if they reach live skin tissue, those particles can damage cell DNA.

Federal agencies

Federal agencies in the U.S. have generally decided that they don't need new power or new mechanisms to regulate nanotechnology. In 2006, the Food and Drug Administration (FDA), which has jurisdiction over pharmaceutical and cosmetic products, said that it could provide oversight on nanotechnology with rules already in place. On its website, FDA says that "existing requirements may be adequate for most nanotechnology products that we will regulate," noting that the chemicals are within size ranges familiar to FDA scientists. The website acknowledges that new requirements may be needed "if new risks are identified" but doesn't acknowledge the unique risks already known for nanoparticles.

The U.S. Environmental Protection Agency (EPA) has taken a similar stance. In January 2008, after years of deliberation, EPA stated its approach to nanoscale substances under the Toxic Substances Control Act (TSCA), one of EPA's main regulatory tools. The most crucial point relates to how EPA defines a unique chemical because TSCA authorizes EPA to regulate only new, not existing, chemicals.

According to EPA, substances will be evaluated according to whether they have unique “molecular identities.” It defines those identities in terms of their formulas, the unique ways in which atoms connect to each other, the spatial arrangement of atoms, the crystalline formations of atoms, and other factors. “Historically EPA has not used particle size to distinguish substances that are known to have the same molecular identity,” EPA states, going on to say that “the Agency intends to continue to apply its current approaches.” EPA’s decision fails to address the way in which nanoscale substances use existing chemistry in novel proportions, thus yielding novel properties.

David Berube, Ph.D., a professor at North Carolina State University and author of *Nano-Hype: The Truth Behind the Nanotechnology Buzz*, was blunt in his assessment of EPA and FDA. The message from both, he told EBN, is: “We have no money and we have no people to do this stuff”—that is, to take an active role in regulating nanotechnology. About EPA, Berube said, “They don’t have the power to force the industry to do the research. They’re just hoping that TSCA is going to be sufficient—that’s why they have the voluntary program.”

In concert with its interpretation of TSCA, EPA officially launched the Nanoscale Materials Stewardship Program (NMSP) in January 2008. This voluntary industry partnership encourages companies working with nanomaterials to report available information, including risk management practices, on nanomaterials they make, process, or use. However, the ultimate goals of the program and possible changes that it might bring to EPA’s interpretation of TSCA aren’t clear.

Jennifer Sass, Ph.D., a senior scientist at the Natural Resources Defense Council (NRDC), says that “the good part” about the voluntary framework is that it is “an intelligent list of basic data that would be good for assessing risk.” But, she said, “by being voluntary you’re catching companies that want to do the right thing, and it’s likely to miss companies not doing the right thing.” Moreover, Sass noted, “It’s sending a message to other agencies and out to the public that there’s no special information that people need” about nanotechnology. “I don’t think they handle regular chemicals well,” she said about EPA. “To say they can handle this without doing anything special is really erroneous.”

Another tool in EPA’s limited arsenal is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). EPA first invoked FIFRA in response to a nanotechnology in November 2006 to regulate claims being made by Samsung about a washing machine that incorporates nanosilver to kill bacteria. EPA’s action essentially labeled the washing machine a pesticide and required it to undergo FIFRA’s registration process, which includes environmental-safety evaluations (see *EBN* Vol. 16, No. 1). But we can’t expect EPA to use FIFRA in many cases. It applies only to pesticides, so whether or not it can be invoked often has more to do with how manufacturer claims are worded than with whether a specific chemical is present.

Europe, where nanotechnology is also active, has been somewhat more aggressive than the U.S. in regulating the nanotech industry, but its approach, using its Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) regulation, is somewhat tentative and is still evolving.

Other initiatives

The OptiNet air-quality monitoring system from Aircuity uses carbon nanotubes in a fluoropolymer matrix as a very strong, inert

Among the more notable U.S. initiatives outside FDA and EPA is the Nano Risk Framework, developed jointly by DuPont and the nonprofit organization Environmental Defense (with EPA funding) and released in 2007. The Framework, intended to guide internal corporate process rather than replace or circumvent regulation, offers “a thorough and usable six-step process for organizations to identify, assess, and manage potential risks.” The steps include profiling a nanomaterial’s life cycle, evaluating the risks it poses, and assessing risk-management options.

The report describes how DuPont has applied the Framework to its own product research. In one case, sun protection for plastics, DuPont is bringing a product to market. In another case, with carbon nanotubes, DuPont identified questions it wants to answer before tube to deliver air samples from individual rooms to an analysis and monitoring system.

moving the materials into products, and in a third case, with a nanoscale iron substance, DuPont decided not to use the material because it is too risky.

Discussing the Framework, Sass told *EBN*, "It's the kind of information that EPA should be collecting, that can be used to make risk assessments or at least hazard identifications." Sass said that the Framework should be a requirement, and an environmental and labor coalition, including NRDC and Greenpeace, rejected the Framework as "a tactic to delay needed regulation and forestall public involvement."

In the absence of stronger direction at the federal level, other plans are taking shape to provide safeguards for nanotechnology. Wisconsin has become the first state in the nation to consider its own reporting requirements, with a group led by a state legislator calling for a registry to monitor production and use of nanoscale materials. Maria Powell, Ph.D., is a University of Wisconsin scientist involved in the effort. "Everyone's focusing on EPA and what it's doing and not doing," she said, "[but] almost all the major statutes give responsibility for monitoring and control to the states." She says that Wisconsin should recognize its responsibility to monitor the nanotech industry in anticipation of more active federal oversight down the line.

Research funding is another way in which the government can influence the safety of nanotechnology, but, here too, observers say it is falling short. According to an analysis by the nonprofit ETC Group, EPA allots no more than 10% of its nanotechnology research funding for environmental benefits and potentially harmful effects. EPA itself estimates that 11% of its funding goes to health and environmental research, but that estimate lumps categories together in a way that may not reflect actual safety research.

Industry representatives that *EBN* spoke with generally didn't express concern about the lack of regulation, but they said they wouldn't object if it increased. "Oversight representing the general public is absolutely appropriate," said Nansulate's Burchill, who continued, "Nobody in this field should object to additional scrutiny at all." Foley of Cheap Tubes told *EBN,* "If there's a safer way of moving nanotubes from this container to this container, and somebody wants to tell me to do that, I don't see any problem." Companies actively promoting increased oversight, however, are few and far between.

What's Ahead

With hundreds of products having moved out of the lab and onto the market, the nanotechnology industry has left its decades-long infancy, when anything was possible and little was known. Both the potential benefits and the risks of nanotechnology have become clearer. Nanotechnology has not yet become as pervasive as past materials revolutions, like plastics, but it could be on that path. According to George Elvin, Ph.D., of Ball State University and author of the report "Nanotechnology for Green Building," at least 20% of all building materials will be nano-enhanced by 2016. Elvin says that nanotechnology will increasingly help the building industry improve the performance of its buildings.

For that to happen, however, many industry observers think we need better regulatory oversight. Although companies aren't asking for greater regulation, some appear open to it. "It's safe to say that private industry learned a lot from the introduction of genetically modified organisms to Europe, and how they were rejected," said Elvin. "They have been a lot more proactive" with nanotechnology. Discussing companies like DuPont who have taken a collaborative role with environmental organizations, NRDC's Sass characterized the industry as being pragmatic about oversight: "They're smart enough to know that if they participate, they'll be part of the conversation" when key decisions are made around regulation and safety issues. With nanotechnology's potential impact on the industry, the green building world may also see a growing need to join that conversation.

– Tristan Korthals Altes

For more information:

Nano Risk Framework:

A Partnership of Environmental Defense and DuPont
www.nanoriskframework.org

U.S. Environmental Protection Administration
Nanotechnology Under the Toxic Substances Control Act
www.epa.gov/oppt/nano/

U.S. Food and Drug Administration
Nanotechnology Task Force
www.fda.gov/nanotechnology/

Sidebar: Navigating Nanotech

Studies point to concerns with nanoparticles and nanotechnology, but significant problems with products on the market have not come to light. At the same time, various industry groups, regulatory agencies, and consumer-protection and environmental organizations have differing perspectives on how to address possible environmental and health concerns. Consumers should inform themselves and decide what stance to take.

• Don't rely on labels to tell you whether nanotech is present in products. Research product categories and common applications, and talk to manufacturers.

• Ask companies if they use nanotechnology and, if so, how they protect workers, consumers, and the environment. Ask how they evaluate risk and how it affects their products and research agenda. Check if they participate in EPA's voluntary stewardship program or follow the Nano Risk Framework.

• As always, consult relevant material safety data (MSD) sheets, product specs, and other relevant sources of safety guidance. Be aware, however, that forms like MSD sheets may not recognize the unique hazards of nanotech.

• Talk to state and federal agencies and lawmakers about your perspective. The regulatory climate on nanotechnology is still evolving.

• When looking to improve the performance of a building, start, as always, with sound design and then choose products and materials that support that design. Compared to design decisions, whether or not a specific product has enhanced properties due to nanotechnology will usually have a smaller effect on overall environmental performance.

• Consider whether a product's nanotech benefits are a good fit for your project. For example, a radiant-barrier coating using nanoparticles may have a high insulation value per inch, but in practice it may not be thick enough to impart much insulation value compared with simply using adequate conventional insulation.

• If a product uses a toxic chemical, such as silver, don't assume that it is less harmful simply because it is marketed as "nano." Toxic chemicals used in smaller quantities due to nanotech are still toxic and may even be more toxic because of their increased surface area. Similarly, nontoxic chemicals may become toxic at the nanoscale.

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