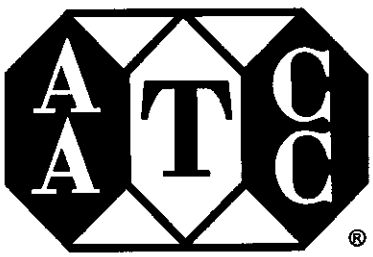


Always Touching Fabric:

By Maria C. Thiry

The textile industry has embraced nanotechnology—especially nanofinishes and nanocoatings—for the tremendous advantages in performance and durability. However, the brave new nano world is not necessarily the utopia it appeared in futurists dreams. More and more experts are calling for a closer look at the possible risks and dangers of this new technology.

How dangerous can nanotechnology possibly be in the textile arena? Assistant Professor Hoon Joo Lee at North Carolina State University's (NCSU) College of Textiles thinks nanotechnology on textiles can be *especially* dangerous simply because of textiles' ubiquity. "After the food we eat, our most intimate relationship is with textiles," she says. "We're always touching fabric."

Water droplet on fabric treated with a nanocoating by P2i Tecnology.

Defining the Risk of Nanotech

Not New

On the other hand, the brave new world of nanotechnology may not be all that new to textiles. Experts say we've been living with nanofinishes for years; we just haven't *called* them nanofinishes. "Many textile finishes have always been nano—they have been nanoscale since they were first invented in the 1970s. It's only recently that they've they been marketed using 'nano' in the wording to describe them," notes DuPont Technical Fellow Robert Buck.

"A lot of this is not new," agrees James Delattre, Nanohorizons vice-president of marketing and product development. "Delustering agents used for polyester for several decades have been nano-scale. Nanotechnology in textiles is not all brand new materials."

Then why has the textile industry "discovered" nanofinishes? What has changed in recent years? "The ability to understand how the materials behave and the ability to design better have improved," says Delattre. "Often, we're using the same material, just more thoughtfully applied, and with better control."

Definition of Nano

So, if the textile industry has been using nanofinishes all along, is it really the same "nanotechnology" the experts are worried about? Just what makes nanotechnology "nano?" Of late, the term has strayed from its strict definition of "less than 100 nanometers" and has taken on the looser connotation of "extremely small."

"We have to educate the consumer about both faces of nanotechnology—the benefits and the risks," says Lee. "We don't want to scare people, but we don't want to downplay the risks either."

Ketchup cleans quickly on fabric treated with nanotechnology for spill resistance provided by Schoeller Textil.

"The word 'nano' is often used more as marketing spin than meaning true nano size," claims Stephen Coulson, chief technical officer for P2i. "Many 'nanotech' finishes are not true nano—they're at the micron level."

"Also, just being a nanoscale material does not, by itself, suggest a special concern about risk," says Buck. "What we really need to ask is whether the material has unique properties *as a result* of its size. And if it does, we need to ask if those properties could create potential risks that we must understand and manage."

Peter Hauser, professor at NCSU's college of textiles, says that the nano-thin coating he's applying to fabric via plasma is not the same thing as individual nanoparticles. "People aren't being exposed to individual nanoparticles," he says. Coulson agrees that nanocoatings pose no more risk than regular coatings. "Our process doesn't create nanoparticles. It's just ultra thin, nano-thickness," he says.

Toxicity

Just what are the risks? How dangerous are nanomaterials? How toxic are they to humans? To the environment? Walt Trybula, professor at Texas State University, says one problem is that the scientists advising regulators don't know all the answers yet, in part because materials on the nanoscale are difficult to measure. "We need a better understanding of materials on a nanoscale," he asserts. "We need to measure at an order of magnitude better than that achievable with the best currently available instruments."

Jennifer Sass, senior scientist at the US Natural Resources Defense Council (NRDC), warns that the very qualities that make a product more useful at the nanoscale could also make it more toxic, or more bioavailable. "Nanoparticles don't necessarily want to stay where you put them; they can surprise you," says Trybula.

Thomas Stegmaier, responsible for research and development in technical textiles, surface treatments, and environmental technologies at the Institute of Textile Technology and Process Engineering (ITV) Denkendorf, notes that generalizing statements of toxicity on nanomaterials may be impossible because not all nanoparticles have the same physical and chemical characteristics. "For

the risk assessment, two variables are crucial: the hazardousness of a substance and the extent of the exposure of an organism [to] the substance."[1]

Stegmaier also notes that routes of nanoparticles exposure, such as "inhalative, dermal, oral, over the eye," should be considered to determine which is "most relevant" in terms of exposure risk. Stegmaier's research, along with that of other experts, reports that lungs are the most crucial organ for the absorption of nanoparticles. On an area of over 130 m^2, airborne nanoparticles can be deposited in the gas-exchange region of the lungs where the cellular barrier for the bloodstream is very thin. Nanoparticles then can be transported to many areas of the body through blood circulation.[1] Associate Professor James James C. Bonner, of the Department of Environmental and Molecular Toxicology at NCSU, agrees that nanoparticles "can reach deeper into the lungs and have more potential [than larger particles] to be toxic."

Consumer Safety

According to Lee, some research says that nanoparticles are easily absorbed through skin tissue. Once the nanoparticles on a fabric are absorbed into a consumer's skin, nothing keeps them from going elsewhere in the body. "Nanoparticles prefer other nanoparticles, and tend to agglomerate into bigger particles," Lee notes. "This can cause a problem in the human body: it can happen in the bloodstream months or years after exposure."

However, Jan Beringer, scientific head of the department of Function & Care for the Hohenstein Institute, feels that as soon as a nanofinish is applied to fabric, it's safe. "Abrasion breaks away [only the] bigger particles—at that point, they're no longer nanoparticles, they're much larger. Once put into a matrix, like fabric, nanoparticles become part of that matrix." Bonner agrees that "if the nanomaterials are in a matrix, they're less likely to come loose."

On the other hand, Lee points to laundering tests, where "we see a reduction in nanoparticles. So we know they're going somewhere, but we don't know where they've gone, or when they left," she says. "We can measure the reduction, but have no idea if the nanoparticles left because of abrasion in the laundry, or abrasion between the fabric and skin," says Lee.

Worker Safety

Consumer exposure may indeed be minimal, but the workers at the finishing plant are another story. "Workers are exposed to the manufacturing process as well as the end product," says Bonner.

Bonner says the US National Institute of Occupational Safety & Health (NIOSH) has no guidelines in place for "safe" exposure levels to nanoparticles. Trybula says that the US Occupational Health & Safety Administration (OSHA) also has no current safety or labeling procedures in place for exposure to most nanoparticles.

Stegmaier notes that recent large scale research projects such as "Nanocare" specifically investigated worker risks from nanoparticles. A large series of industrially relevant nanoparticles were examined to determine their toxicity and incorporation into living organisms. "Important conclusions of the studies of Nanocare are that at a high dosage, the various nanomaterials lead to inflammations; which, however, are a typical reaction to foreign particles and are not nanospecific. None of the examined materials showed an acute toxicity or biological effects at low dosages." [1]

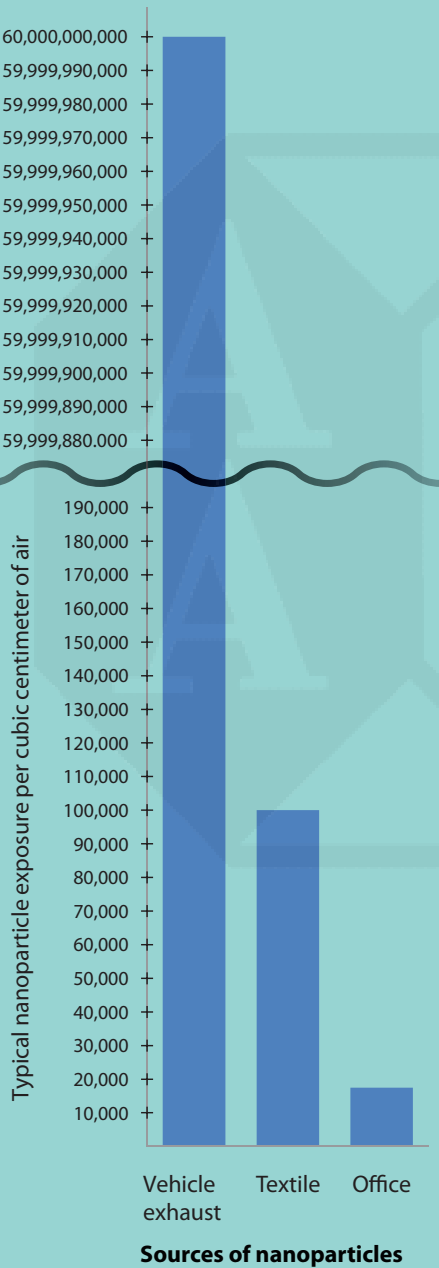
Environmental Safety

If we accept that human beings are relatively safe from nanotechnology, does that mean everything else is? Does nanotechnology pose a threat to the environment? Sass says that researchers have to look into a product's end of life: "Will it be burned,

Water beads on fabric treated with nanotechnology from Schoeller Textil. Schoeller NanoSphere has been tested and certified safe by SUVA, says the company.

Nanoparticles All Around You

Data courtesy of Jan Beringer, Hohenstein Institute



recycled, or dumped? Are nanoparticles released? How does that affect safety?" she asks. Bonner agrees that studies should be done on how textiles with nanomaterials behave over time, with special attention to end of life issues.

Beringer says that Hohenstein is currently involved in doing a lifecycle assessment of nanotreated textiles in the washwater and the environment. He says it's a publicly-funded research project by the ministry of research of Germany "with 16 partners, including universities, government parties, NGOs, and textile companies."

Risk Assessment

Studies are important, but how do companies using nanotechnology assess and mitigate any risks today? Experts agree that it's important to at least consider the possibility of risks posed by nanotechnology. "We are assuming that if the bulk scale material is safe, that the nanoscale is safe, which is an unfounded assumption," says Sass.

On the other hand, Beringer sees no cause for panic. "The nanoparticles now used in nanofinishes for textiles include silicon dioxide, silver, and titanium dioxide: these substances are all already found in nature on the nanoscale. People are already exposed to these substances on the nanoscale," he says. Beringer says that volcano fumes, candle smoke, or any carbon-burning substance, are all sources of nanoparticles. Stegmaier adds forest fires and sea salt particles to "natural" sources of nanoparticles in the air, and motors and heaters to "man-made" sources of nanoparticles. "Very high nanoparticle emissions occur during industrial processes such as welding," he notes.

Although there may be low hazard from common nanomaterials, "a risk assessment still needs information about the exposure of workers or consumers [from] these nanomaterials," says Stegmaier. To assess and mitigate the specific risks posed by nanotechnology used on textiles, and "to answer the consumer-oriented question [of] whether a textile finished with nanoparticles could be a source of danger," Stegmaier says "it is still necessary to know under what stress which nanoparticles are released in which concentration. Exposition data need to be collected to execute a profound risk assessment either by combining exposition and toxicology data or by comparing exposition data with threshold limits."

Schoeller Textil fabric nanotechnology for stain resistance shrugs off honey and soda water.

Delattre agrees that "all chemicals need to be treated with respect. Any company that develops new products, nano or otherwise, has to develop environmental, health, and safety assessments and procedures." He believes that "thoughtful process development can mitigate any risk to reduce exposure to workers." He says that it's "important to characterize, through third party biological testing, what the risks are." Delattre also believes in "third party certification, like Oeko-tex, which is important as a safeguard for consumers."

Buck says that, to aid in risk assessment and mitigation, DuPont worked with the Environmental Defense Fund to publish a "Nano Risk Framework" for companies looking at nanotechnology from a product safety stewardship perspective to help them ask the correct questions about possible risks during the use, handling, and disposal of nanomaterials.

Regulatory Issues & Testing

One of the main risks for companies using nanotechnology doesn't come from the technology itself, and has nothing to do with health and safety—it's the lack of a regulatory framework. It's from using technology that regulators may decide to ban or restrict in the future.

Part of the problem is that it's such a broad field that regulators have been having problems getting a handle on the issues. "Everybody has different policies and definitions of nanotechnology," says Lee. "The [US] Environmental Protection Agency (EPA) does not have a clear definition for nanoparticles or nanomaterials yet. So far, they have looked at nanoparticles in terms of their chemistry rather than their size."

Developing Nanotech Tests

Bonner says that the US National Institute of Environmental Health Sciences (NIEHS) is developing a "relatively quick and inexpensive screening test. NIEHS is funding experiments looking at nanotoxicity on rat cells and human cells, and looking for reproducibility of the tests from lab to lab."

Beringer says another part of the problem is that regulators don't have enough data to say whether certain nanotechnologies are dangerous or safe, so they have no basis for regulations. Bonner and Beringer both say that there's a need to develop efficient screening tests for relative toxicity.

Stegmaier says that ITV Denkendorf just completed a project to develop a test method "for the detailed characterization of the emission of nanoparticles from textiles or their coatings into the air during handling and usage." The project was mandated by the state of Baden-Württemberg, financed by funds

from Landesstiftung Baden-Württemberg GmbH, and supported by members of the textile and textile auxiliaries industries. "The focus of the research project was to measure the exposure [to] nanoparticles during the use of nanoparticle-functionalized textiles, taking the bronchial absorption of nanoparticles as the main potential health hazard," he says.

ITV Denkendorf developed a new test to determine and quantify which air-borne nanoparticles "are releasable from fiber-based materials during processing or usage. Information on particle concentrations, particle size distribution, particle chemistry, and particle form is available. These four important properties can serve for risk assessment."[1]

Recently, the Schweizerische Unfallversicherungsanstalt SUVA (Swiss Accident and Insurance Fund) began monitoring Swiss manufacturing plants that process nanoparticles (including those intended for textiles) with a device developed at the Institute of Aerosol and Sensory Technology at the University of Applied Sciences of Northwestern Switzerland. It's a battery-powered instrument that can be carried by workers in a backpack, and used to monitor the nanoparticles load in the air of a workplace over a number of hours. The device measures the particulate load in the air once per second, and records the data over six hours.[2]

Application Matters

One thing that has emerged from the research so far is that if nanoparticles are being applied to a textile surface, the method of application matters, in terms of health and safety. "As with all textile finishes, it's how you put them together that makes a difference," says Buck.

"If you treat the fabric in an aqueous solution of nanofinish and just let it dry, depending only on Van der Waals force to make it stay on, it will go somewhere else eventually," says Lee. She says that many nanofinishes are applied that way because it's the most economical and convenient way to achieve the finish. "But since the nanoparticles are not chemically grafted onto the fiber, they have the potential to migrate into the human body or into the environment," she says.

Appropriate coating or binding technology is necessary to ensure that any nanoparticles become part of a matrix. "Our tests demonstrated that relevant emissions from a nanoparticle-based coating can be prevented through the correct setup of textile auxiliaries and process technology," says Stegmaier. "The nanoparticles need to be permanently attached to the fiber," says Lee. "If nanoparticles are grafted onto a surface, they're much safer."

Conclusions

What factors are important when considering the potential risks from nanotech on textiles?

First, definitions are important. When talking about the nanotech on a fabric, do you mean "true" nanoparticles, with specific physical properties that are distinct from those demonstrated by the same material in bulk size? Or are you talking about the application of coatings on the nano-scale to textile fibers, or some other variation of tiny tech?

The specific chemistry of the nanotech particles or coatings is of major importance. As is testing that substance for relative toxicity at the nano-size.

The application of the nanotech to the fabric surface is also critical. Nano that's in a matrix, and bound to the fiber itself, has less potential to do damage. Cheaper applications may not be so cheap in the long run if the nanotech escapes and harms human life or the environment.

In the end, is nanotechnology any more dangerous than the other chemical technologies used for textiles? Buck says that chemical suppliers and textile finishers "need to evaluate the risk of *any* material." Delattre agrees that "environmental and worker safety is a standing concern. Constant monitoring and improvement is not a 'nano' issue; it's a good corporate citizen issue."

"We have to be realistic about the risks," says Lee. To put nanotechnology on textiles in perspective, she says they have less potential impact on human health than the side effects of medications people take every day. But, she says, "we still need to do a lot more research about nanotechnology safety."

Notes

1 Stegmaier, Thomas, *et al*, "Test Method for the Emission of Nanoparticles from Textiles in Air," ITV Denkendorf, June 24, 2010.

2 Letter from SUVA, provided by Schoeller Textil AG.