Using Nanotechnology In Sun Care Formulas

In previous columns *(July and September, 2008),* I tackled a number of controversial sun care issues. As a reminder, in today's Information Age, you cannot believe everything you read. Nowadays, anyone can take any sunscreen topic, twist it and use it to promote his or her agenda. Blogging has given voice to an unheard consumer. With this increased online banter, researchers should question the validity of information on the web. This issue will deal with one other important topic that is relevant to the sunscreen industry, namely nanotechnology.

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Nanotechnology is generally used to refer to the development of materials that have at least one measured dimension in the range of 1-100 nanometers.[1] To put a nanometer in perspective, it is about 100,000 fold thinner than the human hair. A sheet of paper is about 100,000nm thick and there are 25,400,000nm per inch. A DNA strand is 2.5nm which is 1000 times smaller than a bacterium (2.5 micrometers in length) and one million times smaller than a rain drop (2.5 millimeters in diameter).[2]

Nanoscience discovers behaviors and properties of materials at the nanoscale level. This technology is utilized to make faster computer chips, tiny medical devices that repair clogged arteries and filters that purify polluted water. Two Nobel prizes in chemistry were recently awarded in the field of nanotechnology—in 1996 to Richard Smalley, Rice University, who laid the foundation for nanotechnology and in 1999 to Ahmed Zuwail, Cal Tech, for his work on femtochemistry (10^{-15}nm particles).

Dr. Smalley defines nantechnology as "the art and science of building stuff that does stuff at the nanometer scale."[3] Andrew Maynard of the Woodrow Wilson Center, describes nanotechnology as "diverse, global, and powerful. A new way of engineering the world to achieve our goals makes it diverse. Eventually, its impact will be felt around the world in every community. While it will change our world in a powerful way, the power if offers must be used responsibly if global benefits are to be realized."[4]

Nanoscale materials have significantly different physico-chemical properties than in their original state. In fact, chemists are calling for a modified Periodic Table to illustrate the behavior of nanoparticles.[5] The particles are so tiny that the electrons are squeezed into a space smaller than they prefer. In this "quantum confinement," a smaller crystal leads to greater electron energy. As its kinetic energy is increased, its wavelength shortens. When particles are that small, the surface area of the material expands dramatically. More surface area yields more reactions. At this scale, properties of materials can change, giving one the ability to do new and unique things, such as create more effective drugs, stronger, more flexible materials and more nutritious, longer-lasting foods.

Nanotechnology has the potential to affect many fields, from consumer products to energy to medicine. For example, replacing less-than-ideal crystal solar cells with polymer-based, nano-solar cells to harness sunlight energy more efficiently. Mimicking nature and the process of photosynthesis with more efficient nano-based photovoltaics will lead to energy self-sufficiency.

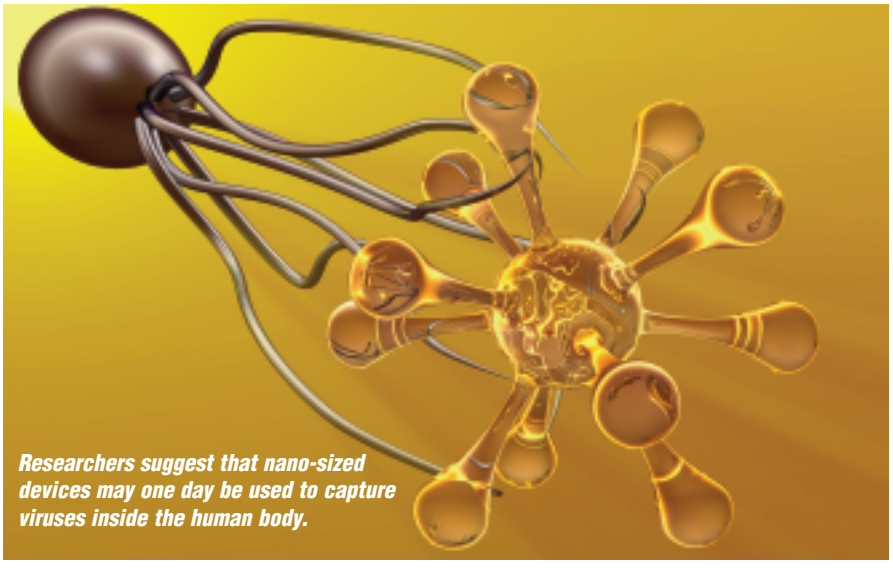
Some Concerns

But some of the properties that make nanotechnology exciting also raise concern. Little research has been done on the potential risks of nanotechnology and nanomaterials, some of which could have serious impacts on the environment and human health and safety. Unlike conventional particles, nanoscale materials may reach the bloodstream. This feature has obvious benefits in drug and medical device design, but also the potential for unanticipated adverse effects.[6] In December 2006, Berkley, CA amended its hazardous material law to regulate nanoparticles, and Cambridge, MA is considering a similar ordinance.

With nanotechnology being incorporated into an increasing number of personal care and sunscreen products, a new group is investigating the potential risks it may pose to the environment and human health. The National Nanotechnology Initiative

(NNI) encompasses activities related to nanotechnology across the U.S. federal government and includes a research component to understand the associated risks. The current strategy that the NNI is working toward will focus on nanomaterials and their effect on human health and the environment.[7]

Today, more than 600 consumer products use nanotechnology. A recent report from BCC Research estimates the global market for cosmetics using nanotechnology is currently valued at $62 million and will grow 16.6% annually to reach $155.8 million by 2012.[8]



Researchers suggest that nano-sized devices may one day be used to capture viruses inside the human body.

Nanotechnology and Cosmetics

Nanotechnology applications, including cosmetics and OTC drugs, are regulated by the U.S. Food and Drug Administration.[9] FDA seeks feedback from the cosmetics industry to develop the recommendations for its Nanotechnology Task Force, which was created in 2006 to determine the safe and effective use of nanotechnology materials in cosmetics. FDA also seeks information on the availability, practicality and reliability of these tools and maintains it will work with the industry to develop new techniques if necessary.

Micronized titanium dioxide and zinc oxide have been used in sun care products for many years. They provide greater protection, especially from UVA rays, and also are aesthetically more appealing to the consumer with their clear protective barrier. Both TiO2 and ZnO are Category I ingredients that can be used at levels up to 25% in sun care products. There are concerns in Europe about the use of ZnO in sun care products. Even though both ingredients are perceived as natural inorganic raw materials, the process of extracting them from ore, coating and emulsifying them, requires primarily synthetic chemicals and processes. In addition, nanoparticle micronization has raised concern among consumer and environmental groups. The Biological Farmers of Australia (BFA) proposed organic certification only be applied to nano-free products. Andrew Monk, BFA standards chair, said that the decision is a result of a growing body of evidence that human-made nanoparticles introduce novel toxicity risks and the fact that the technology has yet to be proven safe. The move echoes that of the UK-based Soil Association, which banned the use of nanoparticles in organic certified cosmetic products earlier this year.[10] On May 17, 2008, Friends of the Earth, Greenpeace and the International Center for Technology Assessment called on the FDA to treat nanoparticles "as a new substance and that nanomaterial products be labeled to delineate all nanoparticle ingredients." The British Royal Society concluded in its 2004 report that nanoparticles are different from anything humans have ever created before and that we need to take a precautionary approach.[11]

TiO2 and ZnO nanoparticles have been extensively evaluated for their safety and the scientific data, with few exceptions, so far shows that they do not penetrate the skin. In July 2007, the Nanotechnology Task Force reported that "the current science does not support a finding that classes of products with nanoscale materials necessarily present greater safety concerns than classes of products without nanoscale materials,[9] and concluded that there is no need for products containing nanoscale materials to be labeled as such. Other studies on the safety of nanoparticles are cited on the Personal Care Product Council's website.[1]

Safety Testing

Research carried out recently at the University of Wisconsin-Madison Survey Center suggests that only 29.5%of Americans consider nanotechnology to be morally acceptable.[12] This makes the task of marketing nanotech-based products challenging and could hinder the development of commercial applications. Nanotechnology is currently used in 85 personal care products according to an inventory compiled by the Project on Emerging Nanotechnologies at the Woodrow Wilson International Center. Results of the limited testing that has been done provide reason for concern: carbon nanotubes can irritate lungs in a way similar to asbestos; some nanomaterials, when tested on rats, pass from nerve endings in the nose to the brain, bypassing the blood-brain barrier; and some nanomaterials can interact with DNA. These substances could have widespread negative impact on environmental and human health, as well as consumer confidence.[13]

Last month, a dozen or so blogs proclaimed "Nanoparticles can seep through skin." The authors based their information on the studies conducted by scientists at the University

of Rochester Medical Center, which found that nanoparticles can breech the skin barrier, especially when the skin has been damaged by the sun. The paper was published in the September 2008 issue of the *Journal of Nano Letters* by Dr. Lisa Delouise et al. The team studied the penetration of nanoparticles cold quantum dots that floresce through the skin of certain mice. The mice were exposed to about the same amount of ultraviolet light as might cause a slight sunburn to a person. Part of the explanation lies with the complex reaction of skin to the sun's rays where cells proliferate and molecules in the skin known as tight-junction proteins loosen so that new cells can migrate to where they are needed. Those proteins normally act as gatekeepers that determine which molecules to block and which to allow through the skin and into the body. When the proteins loosen up, they become less selective than usual and possibly allow nanoparticles to pass through the skin barrier.[14] Delouise points out that her study did not directly address the safety of nanoparticles in any way. The team plans to study TiO2 and ZnO soon.[15]

The Nanotechnology Industries Association (NIA) has criticized the University of Rochester report stating that the results cannot be interpreted as applying to sunscreens that use TiO2 and ZnO. Scientists have used an in-vivo skin model that the NIA criticized for not being representative. They also state that the mouse stratum corneum of the mice is much thinner than in humans and therefore more easily disrupted.[16]

Friends of the Earth issued an extensive consumers guide for avoiding nano-sunscreens with the statement "sun worshipers beware" claiming the sunscreen manufacturers are adding nano-particles of ZnO and TiO2 without appropriate labeling or reliable safety information.[17] They investigated 120 sunscreen manufacturers and found only nine that claimed their products are nanoparticle free, 24 that had nanoparticles and 95 brands were unclear or did not respond to the survey. They cite three scientific studies that show that nanoparticles used in sunscreens can damage DNA,[18] disrupt function of the cells[19] and cause cell death.[20]

L'Oréal's Gerhardt Nohynek and scientists from the University of Queensland in Australia conclude in their intensive investigation that "overall, the current evidence suggests that nanosized cosmetic or sunscreen ingredients pose no potential risk to human health, whereas their use in sunscreens has large benefits, such as a protection of human skin against skin cancer."[21] They argue that it is uncertain that cosmetic formulations with nano-emulsions and microscopic vesicles of ZnO and TiO2 should be qualified as actual nanomaterials. Vesical materials do not penetrate into living human skin but may enhance or reduce skin absorption of ingredients. They cited in-vivo toxicity test results that showed both ZnO and TiO2 nano particles are nontoxic. In-vitro and in-vivo cytotoxicity, genotoxicity, photogenotoxicity, acute toxicity, sensitization and ecotoxicology studies on TiO2 nanoparticles found no difference in the safety profile of micro- or nano-sized materials, all of which were nontoxic. They acknowledge, however, that some in-vitro investigations on TiO2 particles reported cell uptake, oxidative cell damage or genotoxicity, but conclude that these results may be secondary to phagocytosis of cells exposed to excessive particle concentrations.

Conclusions

Nanotechnology is at the forefront of cosmetic innovation. Despite its promise, scientists remain concerned about potential health and environmental risks. After reviewing the pros and cons of nanoparticles in sunscreens, I don't think the verdict is in yet. A range of opinions regarding nanoscale zinc oxide and titanium dioxide are available on popular websites such as Tree Hugger, Huffington Post, the Green Guide and others, which included the headline "Nono to Nano!"

The L'Oréal and Australian study concluded that fears about nanoparticles penetrating the skin, accessing to the lymphatic system, and circulating around the organism is "simplistic and physiologically improbable." The one thing that everyone seems to agree on is that the lack of safety data makes it hard to draw definitive conclusions regarding the safety of nanomaterials in sunscreens.

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