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Do Nanoparticles and Sunscreen Mix?

Your first encounter with "better" living through nanotechnology may be your sunscreen

By David Biello

Sunscreens shield human skin with chemicals that either absorb or deflect damaging ultraviolet rays, most often titanium dioxide or the zinc oxide known best as the white stuff lifeguards slather on their noses. But it seems they (and others) don't have to put up with the white mess: Zinc oxide can be made clear—and remain just as, if not more, effective as a sunblock—by shrinking it into tiny particles between one and 100 nanometers. (A nanometer equals one billionth of a meter, or 3.94×10^{-8} inches—roughly half the size of a strand of DNA.)

While ideal for image-conscious sun worshippers, however, some environmentalists charge that more research is needed to rule out potential health and environmental risks of reducing chemicals to nanoscale proportions, which can dramatically alter their physical properties. Pencil lead, for instance, becomes stronger than steel when reduced into nanosize atomic clusters.

The question is: "How can something that is so innocuous at bulk size become such a devil at small size," says neurotoxicologist Bellina Veronesi of the Environmental Protection Agency (EPA).

Concerned about such ambiguity, the environmental group Friends of the Earth in Washington, D.C., has called for a ban on use of nanoparticles in sunscreen pending further study, citing results of a survey it conducted of sunscreen manufacturers released this week.

Of the 128 companies surveyed, only 38 agreed to participate; of that number, just nine said they did not use nanoparticles in their sun salves. "The biggest fear is that any time you reduce something to nanoscale, you are really dealing with a whole new set of rules for reactivity that we really don't understand right now," says Ian Illuminato, Friends' health and environment lobbyist who conducted the survey. "There [are] just not enough studies to give us confidence that this is not going to hurt people."

Veronesi, who studies nanosize titanium dioxide, found that it had no effect on mouse brain cells in vitro, but did affect microglia (specialized immune cells) from the animals' nervous systems. At a concentration of just 10 parts per million, photoactive titanium dioxide nanoparticles infiltrated the microglia and caused them to produce free radicals—charged oxygen particles—that are protective in the short term but wreak havoc when continuously released, because they stress healthy cells.

But Veronesi points out that the nanoparticles she studied are not the ones that would most likely be used in a sunscreen. She studies photoactive titanium dioxide, nanoparticles proposed to be used to help break down chemical contamination in polluted areas by enhancing sunlight's effects. Sunscreen manufacturers are more likely to use coated nanoparticles of titanium dioxide, she says, designed to deflect sunlight. "I would imagine that [company] scientists would not want to use a photoactive product," Veronesi says. "That would be a mistake because you are then coating your skin with a nice layer of free radical generating stuff."

Further, it is not clear how nanosize titanium dioxide or zinc oxide could pass from the skin to organs such as

the liver or brain where they might do damage. Of 15 scientific studies conducted by government, industry and independent researchers over the past decade, only one found that nanoparticles were absorbed by the skin of rabbits; none detected human skin penetration, even with an electron microscope.

Nevertheless, the finding shows how compounds that are innocuous at larger sizes may reveal a dark side when nanoscaled. And Friends of the Earth complains there have not been enough studies conducted to assess how nanoparticles interact with other chemicals in various sunblocks. "It is jumping the gun to say that nanoparticles cannot penetrate the skin," Illuminato argues. At the very least, he says, manufacturers should be required to label products that contain nanoparticles.

Scientists studying titanium dioxide and zinc oxide, however, have found that the compounds are most effective at blocking UV rays when nanosize. And they are among the only chemicals capable of shielding both UVA (skin-wrinkling) and UVB (cancer-causing) rays and, therefore, of fending off potentially deadly skin cancer. This disease, which affects some one million Americans each year, a number that continues to grow, according to the Centers for Disease Control and Prevention, is primarily caused by UV exposure.

Therefore, the Environmental Working Group (EWG) recommends using sunscreens that contain zinc oxide or titanium dioxide, nanosize or not. EWG also prefers these formulations because studies show that sunscreens containing alternative organic chemicals such as oxybenzone and octinoxate seep through the skin into the body where they can sometimes behave like the hormone estrogen, prompting abnormal activity in the human reproductive system, among other things. In addition, the group says, the zinc oxide and titanium dioxide formulations utilize fewer other chemicals, some of which are known or suspected to cause cancer and

damage the brain or immune system.

After testing some 800 different sunscreens, the EWG found that those without zinc and titanium "could accelerate by an average of 20 percent the skin damage, premature aging wrinkling and UV-induced immune system damage linked to UVA exposure."

The fundamental problem is a lack of information: No one other than the manufacturers know the exact ingredients in their products and little safety testing has been done or documented on the vast majority of chemicals commonly used in sunscreens. Because they are classified as over the counter drugs, the Food and Drug Administration (FDA) has the authority to regulate the active ingredients (like titanium dioxide or zinc oxide that protect the skin) in a sunscreen but it does does not regulate inactive ingredients, such as preservatives or emollients. Rather, manufacturers must "substantiate" safety with their own clinical trials, or avoid the whole process by simply placing a warning on product labels noting safety has not been determined.

The Royal Society (the U.K.'s national science academy) three years ago advocated peer-reviewed, publicly accessible safety studies for any cosmetics containing nanoparticles, and some U.S. lawmakers have also urged stricter safety rules—a call that has yet to be heeded.

The FDA last month nixed new regulations governing the use of nanoparticles in personal care products noting that previous studies showed larger versions of the same compounds were safe. "Current regulations dealing with cosmetics are pretty weak, because they don't require any pretesting" on humans, says physicist Andrew Maynard, chief science advisor to a project on emerging nanotechnologies at the Woodrow Wilson International Center for Scholars (a Washington, D.C., think tank created by Congress in 1968). "If you bring a new technology along that has even more uncertainty than common chemicals, it really focuses a spotlight on that issue."

The EPA reviews new chemicals for toxic implications, but lacks comprehensive data to assess nanosize ones in the 90 days it has to do so. "We have developed a growing need for data on the environmental and health implications of nanomaterials to help us review them. As we looked at the data available [from companies and elsewhere], it has become clear that it is widely variable," says Jim Willis, director of the EPA's chemical control division. "The number one issue is data availability."

The EPA and several programs of the National Institutes of Health are working to fill that gap by studying the health and environmental impacts of various nanoparticles. But funding is scarce. "I would like to look at it in animals," EPA's Veronesi says. "For that we really need technical support and resources so we're shelving a lot of ideas right now."

The best advice, researchers say, is stay out of the sun, especially between 10 A.M. and 4 P.M. when it is most intense. But if you can't, be sure to use a sunblock that provides protection from the broadest possible range of ultraviolet rays, primarily offered, EWG says, by sunscreens containing zinc oxide. If it goes on clear,

it probably contains nanosize bits of the compound. But experts say the risk of developing potentially fatal skin cancer outweighs the potential dangers posed by such nanoparticles.