New approach to testing health, environmental effects of nanoparticles

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Earlier efforts to determine the health and environmental effects of the nanoparticles that are finding use in hundreds of consumer products may have produced misleading results by embracing traditional toxicology tests that do not take into account the unique properties of bits of material so small that 100,000 could fit in the period at the end of this sentence.

That was among the observations presented here today at the 245th National Meeting & Exposition of the American Chemical Society (ACS), by one of the emerging leaders in nanoscience research. The talk by Christy Haynes, Ph.D., was among almost 12,000 presentations at the gathering.

Haynes delivered the inaugural Kavli Foundation Emerging Leader in Chemistry Lecture at the meeting, being held in the Ernest N. Morial Convention Center and downtown hotels. Sponsored by the Kavli Foundation, the Emerging Leaders Lectures recognize the work of outstanding young chemical scientists. These new presentations will shine the spotlight on scientists younger than 40 years old and not more than 10 years removed from earning their Ph.D.s when nominated, and who have made exceptional achievements in scientific or engineering research. This lecture series will run from 2013 to 2015 and joins the existing "Kavli Foundation Innovations in Chemistry Lecture" series.

"Christy Haynes is the perfect scientist to launch this prestigious lecture series," said Marinda Li Wu, Ph.D., president of the ACS. "Haynes' research is making an impact in the scientific community in efforts to use nanoparticles and nanotechnology in medicine and other fields. And that research has sparked the popular imagination, as well. Haynes was included in *Popular Science*'s 'Brilliant 10' list, a group of 'geniuses shaking up science today.' We are delighted to collaborate with the Kavli Foundation in highlighting the contributions of such individuals."

"The Kavli Foundation is delighted to support a series that brings attention to exceptional young researchers in chemistry. Recognizing these outstanding young chemists will inspire others and help create a vibrant future in the field," said Fred Kavli, founder and chairman of The Kavli Foundation. Added Bob Conn, president of the foundation, "Bright, young researchers possess the energy, motivation and a 'can do' attitude to move science forward. It is often at this stage that scientists do their most innovative work."

The Kavli Foundation is dedicated to advancing science for the benefit of humanity, promoting public understanding of scientific research and supporting scientists and their work. The Foundation implements its mission through an international program of research institutes in the fields of astrophysics and theoretical physics, nanoscience and neuroscience, and through the support of conferences, symposia, endowed professorships, journalism workshops and other activities.

The "Kavli Foundation Innovations in Chemistry Lecture" series debuted in March 2011 and will continue through 2013. These lectures will address the urgent need for vigorous, new, "outside-the-box" thinking, as scientists tackle many of the world's mounting challenges, like climate change, emerging diseases, and water and energy shortages. The Kavli Foundation, an internationally recognized philanthropic organization known for its support of basic scientific innovation, agreed to sponsor the lectures in conjunction with ACS in 2010.

Wu also praised The Kavli Foundation for its support of the lectures and leadership on a broad range of other activities in advancing science. "The Kavli Foundation and the American Chemical Society are excellent partners with remarkably similar missions," Wu said. "ACS' mission statement speaks of advancing the science of chemistry 'for the benefit of Earth and its people.' I am delighted that these two organizations can work together in their dedication to achieving these goals."

Haynes, who is with the University of Minnesota, explained that as manufacturers began using or considering use of nanoparticles in consumer and other products, concerns emerged about the possible health and environmental effects. More than 800 consumer products based on nanotechnology are on the market, according to some estimates. A new field sometimes termed "nanotoxicology" emerged in the last 10 years to investigate those concerns.

"Initial work focused on using the toxicology tests that had been used for years to evaluate bulk materials," Haynes said. "Nanoparticles, however, are inherently different. A nanoparticle of material used in food or a cosmetic lotion may contain just a few atoms, or a few thousand atoms. Regular-sized pieces of that same material might contain billions of atoms. That difference makes nanoparticles behave differently than their bulk counterparts."

A 1-ounce nugget of pure gold, for instance, has the same chemical and physical properties as a 2-ounce nugget or a 27-pound gold bar. For nanoparticles, however, size often dictates the physical and chemical properties, and those properties change as the size decreases.

Haynes said that some of the earlier nanotoxicology tests did not fully take those and other factors into account when evaluating the effects of nanoparticles. In some cases, for instance, the bottom line in those tests was whether cells growing in laboratory cultures lived or died after exposure to a nanoparticle.

"While these results can be useful, there are two important limitations," Haynes explained. "A cell can be alive but unable to function properly, and it would not be apparent in those tests. In addition, the nature of nanoparticles—they're more highly reactive—can cause 'false positives' in these assays."

Haynes described a new approach used in her team's work in evaluating the toxicity of nanoparticles. It focuses on monitoring how exposure to nanoparticles affects a cell's ability to function normally, rather than just its ability to survive the exposure. In addition, they have implemented measures to reduce "false-positive" test results, which overestimate nanoparticle toxicity. One of the team's safety tests, for instance, determines whether key cells in the immune system can still work normally after exposure to nanoparticles. In another, the scientists determine whether bacteria exposed to nanoparticles can still communicate with each other, engaging in the critical biochemical chatter that enables bacteria to form biofilms, communities essential for them to multiply in ways that lead to infections.

"So far, we have found that nanoparticles made of silver or titanium may be the most problematic, though I would say that neither is as bad as some of the alarmist media speculations, especially when they are stabilized appropriately," said Haynes. "I think that it will be possible to create safe, stable coatings on nanoparticles that will make them stable and allow them to leave the body appropriately. We need more research, of course, in order to make informed decisions."

This area of research—how nanoparticles interact with biological and ecological systems—is the focus of a newly funded multi-institutional partnership that includes Haynes' team. It is the Center for Sustainable Nanotechnology, funded by the National Science Foundation Division of

Chemistry through the Centers for Chemical Innovation Program.

Haynes' work has led to her involvement in two large bioethics efforts funded by the National Institutes of Health that made recommendations about how to regulate nanoparticles for biomedical use. "I was one of a few scientists in rooms full of lawyers, ethicists and philosophers," she explained. "My job was to provide the bench scientist's perspective on the definitions and recommendations. Both projects produced recommendations that were presented directly to officials in the U.S. Food and Drug Administration, the U.S. Environmental Protection Agency, the National Institute for Occupational Safety and Health and other agencies."

More information: Abstract

The topic of nanoparticle toxicity is relevant to both food and energy because engineered nanoparticles are increasingly being incorporated both into food products and devices for energy production – this means that engineered nanoscale materials will either intentionally or unintentionally be released into the ecosystem and the human body. The long-term goal of work in this field is to understand the molecular design rules that control nanoparticle toxicity using aspects of materials science (nanoparticle design, fabrication, and modification), analytical chemistry (developing new assays to monitor nanotoxicity), ecology (monitoring how nanoparticles enter and accumulate in the food web through bacteria and how these nanoparticles influence bacterial function), biology (considering the implications of mammalian exposure to engineered nanoparticles), and ethics (discussing the ethical implications of "disruptive" technology). Taken together, these data suggest that careful consideration of engineered nanoparticle surface chemistry will likely allow design of safe and sustainable nanoscale materials.

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