STATEMENT OF
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BEFORE THE
COMMITTEE ON SCIENCE
UNITED STATES HOUSE OF REPRESENTATIVES
September 21, 2006

Introduction. Thank you, Mr. Chairman and Members of the Committee for the invitation to appear here today and provide testimony on nanotechnology research at the Environmental Protection Agency (EPA). I am William Farland, Deputy Assistant Administrator for Science for the Office of Research and Development. EPA is a leader in promoting research to develop environmental applications and understand potential implications of nanotechnology, and vigorously pursues collaborations with U.S. and international scientists and policymakers. My purpose today is to describe our research needs in this area, and how EPA is going about meeting these needs.

EPA recognizes that nanotechnology has the potential to improve the environment, both through direct applications to detect, prevent, and remove pollutants, as well as by using nanotechnology to design cleaner industrial processes and create environmentally friendly products. However, some of the same unique properties that make manufactured nanoparticles (which in the remainder of this testimony I refer to simply as "nanoparticles," recognizing that our focus is on particles intentionally manufactured at the nanoscale) beneficial also raise questions about the impacts of nanoparticles on human health and the environment. The evaluation of potential nanoparticle toxicity is complex, possibly being regulated by a variety of physicochemical properties such as size and shape, as well as surface properties such as charge, area, reactivity, and coating type on the particle. As products made from nanoparticles become

more numerous, the potential for release of nano-size particles into the environment may also increase. The EPA, under its various statutes, has an obligation to ensure that potential environmental risks are adequately understood and managed. Certain EPA programs are already reviewing information on nanomaterials to assess and understand risks and take control measures as needed. For example, EPA is reviewing premanufacture notifications on nanomaterials that have been received under section 5 of the Toxic Substances Control Act. It is important that throughout our evaluation of nanotechnology, decision making be informed by the best available scientific information.

EPA began funding research on nanotechnology under its Science to Achieve Results (STAR) program in 2001. Some 36 grants totaling nearly $12 million have been funded since that time to identify beneficial environmental applications, addressing prevention, sensors, treatment, and remediation of conventional pollutants using nanotechnology. In addition, through its Small Business Innovation Research program EPA has supported projects addressing nanotechnology applications.

Beginning in 2003, EPA turned its focus to the potential environmental implications of nanotechnology and has now funded an additional 30 implications projects totaling approximately $10.4 million under the STAR program. This research is addressing potential human and environmental toxicity, exposure, and fate and transport of nanoparticles in the environment. EPA has partnered with the National Science Foundation, National Institute for Environmental Health Sciences (NIEHS), and National Institute for Occupational Safety and Health (NIOSH), which have funded additional projects under these solicitations. Currently, EPA and the three partner agencies are reviewing the proposals from the latest joint solicitation to make new funding decisions.

Research Needs. While some of EPA's research needs are shared by other federal agencies, EPA has particular needs to support its statutory mandates. To that end, EPA must set research priorities that reflect these program needs. EPA plans to issue its *Nanotechnology White Paper,* released in December 2005 as a review draft that describes EPA's nanotechnology research needs. This research is in the following broad areas: chemical identification and characterization, environmental fate, environmental detection and analysis, potential releases to the environment and human exposures, human health effects assessment, ecological effects assessment, and environmental applications.

Chemical identification and characterization. A number of properties will need to be considered in order to characterize nanoparticles for the purposes of evaluating hazard and assessing risk. Terminology and nomenclature also need to be standardized. EPA is participating in deliberations with the American National Standards Institute, the American Society for Testing and Materials, and the International Organization for Standardization regarding the development of terminology and chemical nomenclature for nano-sized substances, and will also continue with its own nomenclature discussions with the Chemical Abstracts Service.

Potential releases and human exposures. Workers may be exposed to particles during the production and use of materials made from nanoparticles, and the general population may be exposed to releases to the environment during these materials' production or use in the workplace, during the use of commercially available products containing nanoparticles, and during disposal and recycling stages. Workers who manufacture materials made from nanoparticles may be exposed to higher levels of nanoparticles than the general population, and therefore may need additional personal protective equipment. Research is needed to better understand these exposures.

Environmental detection and analysis. The challenge in detecting nanoparticles in the environment is not only their extremely small size but also because the metric of importance is unknown. Consequently we are currently unsure of what to measure and detect. The chemical properties of particles at the nanometer size may require new analytical and detection techniques. To that end, we need to assess available detection methods and technologies for nanoparticles in environmental media, and to develop a set of standard methods for the sampling and analysis of nanoparticles of interest in various environmental media.

Environmental fate. As more products are developed using nanoparticles, there is increased potential for releases of nanoparticles into the environment. Particles may be released to the environment during their manufacture and processing, or as they break down during use, disposal, or recycling. We need to understand what happens to these particles as they are released into and move through the air, soil, and water.

Human health effects. Very little data exist on the toxicity, hazardous properties, translocation, and ultimate fate of nanoparticles in humans. We need to understand whether adverse health effects may result from exposure to nanoparticles or their byproducts, by local toxic effects at the site of initial deposition as well as by systemic toxic responses. Toxicological assessment of manufactured nanoparticles will require information on the routes (inhalation, oral, dermal) that carry the greatest potential for exposure to nanoparticles.

Ecological Effects. Research is needed on the potential exposure and effects of nanoparticles on invertebrates, fish, and wildlife. Furthermore, dispersion of nanoparticles in the environment may result in novel byproducts or degradates that also may pose hazards. We need to understand the behavior of nano materials in aquatic and terrestrial environments, and nanoparticles' potential acute and chronic toxic effects. To do this, we need to develop and

validate analytical methodologies for measuring nanoscale substances (both parent materials and metabolites/complexes) in the environment.

Environmental Applications. Nanotechnology can help create materials and products that will not only directly advance our ability to detect, monitor, and clean-up environmental contaminants, but also help us avoid creating pollution in the first place. By using less materials and energy throughout a product's lifecycle—such as by using highly reactive nanoparticles as more-efficient catalysts—nanotechnolgoy may contribute to reducing pollution and energy consumption. Research is needed to advance the use of nanotechnology to enhance environmental protection.

EPA Research. Based on the fiscal year 2007 President's budget request of $8.6 million, EPA is developing a nanotechnology research framework for fiscal years 2007-2012 that is problem-driven, focusing on addressing the Agency's programmatic needs. EPA will conduct research to understand whether nanoparticles, in particular those with the greatest potential to be released into the environment and/or trigger a hazard concern, pose significant risks to human health or ecosystems, by looking at the life cycle of nanoparticles**.** Also, EPA will conduct research to identify approaches for detecting and measuring nanoparticles in the environment, and for using nanotechnology for pollution prevention and enhancing manufacturing processes, as well as to facilitate the development of nanotechnology-based materials in an environmentally benign manner.

This research program will be based on the recommendations from the *EPA Nanotechnology White Paper*, which was developed by a cross-agency committee working under the auspices of our Science Policy Council. Our research will be guided by the information needed to conduct assessments of risk to humans and the environment. We are uniquely positioned to lead in the ecosystem and exposure areas, due to our existing expertise in these

areas. Also, because of expertise in areas such as fine particulate toxicology, we plan to engage in a limited amount of human health effects research. However, we also will look to partnerships and collaboration with other agencies to fill our research needs. For example, we are currently working with NIEHS to ensure that human toxicity research is conducted that is relevant and timely for environmental decision making.

Because the President's budget request proposes to significantly increase EPA's nanotechnology research budget in 2007, I believe the Agency is well positioned to examine the potential human health and ecological risks from nanoparticles.

Collaboration. To meet the research needs outlined here, we need a collaborative approach that will energize the research community, public and private. EPA scientists are leaders in explaining how we can use nanotechnology to improve our environment and how we can improve our understanding of any potential adverse effects resulting from the production, use, disposal and recycling of materials that contain nanoparticles. We intend to continue these efforts and to increase direct collaborations on the research discussed above.

As a member of the National Science and Technology Council's Nanoscale Science, Engineering and Technology Subcommittee, which manages the National Nanotechnology Initiative, EPA plays a leadership role in the coordination of federal activities concerning nanotechnology and the environment. The Agency is also a pivotal member of the Subcommittee's Nanotechnology Environmental and Health Implications (NEHI) working group, whose membership includes, among others, EPA, Food and Drug Administration, Consumer Products Safety Commission, NIOSH, Department of Defense, Department of Energy, and NIH. The NEHI has prepared a research needs document, in the development of which EPA has played a central role, that complements our white paper.

EPA is also engaged in international collaboration. For example, EPA is part of the Organisation for Economic Co-operation and Development effort to address the topic of the implications of manufactured nanomaterials among its members under the auspices of the Joint Meeting of the Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology.

Conclusion. EPA recognizes the potential of nanotechnology to clean up the environment, prevent pollution, and contribute to the sustainable use of resources. EPA is also committed to improving our understanding of the properties of nanoparticles, the behavior of nanoparticles in the environment, and the potential for unintended consequences for humans and the environment from exposure to nanoparticles. The Agency will continue to play a domestic and international leadership role to better understand the environmental issues surrounding this and other emerging technologies. Mr. Chairman, I would like to thank you and the Committee for inviting EPA to participate in this hearing and for giving us this opportunity to describe our nanotechnology research program. I would be happy to answer any questions that you may have.