Health Effects of Nanoparticles

Nanotechnology research is producing remarkable advances for detecting, treating, and preventing health problems. However, while nanoparticles can lead to breakthrough applications, they may also cause hazardous side effects. By examining how substances behave at the individual cellular level, researchers at the University of Maryland exploit the vast potential of nano-scale materials by developing applications that are both effective and safe.

Michael Zachariah works with the National Institute of Standards and Technology to measure nanoparticles precisely and catalog their effects on everything from individual cells to the environment. Specific and consistent manufacturing and measuring are critical for determining the properties of nanoparticles, including toxicity factors and side effects.

Elisabeth Smela and Gary Rubloff work with biocircuits that monitor cell responses to nanoparticles, in real time. Their research markedly improves pathogen detection and rapid toxicity testing for clinical drug trials. http://www.nanocenter.umd.edu/faculty/faculty_list.php

"Rightsizing" Nanoparticles for Safer Health Applications

Determining the toxicology of particles and ensuring quality control are crucial for developing all nanotechnology applications. To those ends, the Co-Laboratory for Nanoparticle Based Manufacturing and Metrology (NM^2) – a collaborative effort between the University of Maryland and the National Institute of Standards and Technology (NIST) – invents equipment, instrumentation, and methodologies for gauging the health effects of nanoparticles. The laboratory also supplies toxicologists with precisely sized particles for cell culture and animal testing.

Michael Zachariah manages the NM^2, which makes, measures, and characterizes nanoparticles, including those with special bio-medical properties. For example, the laboratory characterizes carbon nanotubes and gold nanoparticles, both used for diagnostics and targeted drug delivery. As more materials such as these are created, manipulated, and then manufactured on a large scale, questions of safety become increasingly important. NM^2 therefore develops research protocols needed to standardize toxicology for nanotechnology research. No one yet understands the health impact of nanoparticles, and no research team is better positioned than Zachariah's to establish industry standards for investigating toxicity.

Zachariah's work supports innovations across the spectrum of nano-based health applications. He characterizes pathogens, runs tests for optimizing drug dosages, synthesizes aerosol materials with unique properties, develops thin film deposition methods, improves nano-based modeling devices that facilitate gas-to-particle conversion, and creates technologies to study cellular reactions to nanoparticles in real time.

Yet another health application Zachariah examines is the effect of diesel soot on the environment. Diesel soot, a nanoparticle that appears to contribute significantly to global warming, contains metal traces that might be manipulated to prevent its release into the atmosphere. Zachariah's research provides data for computer models that measure and predict global warming.

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Cell-Based Sensors for Real-Time Toxicological Monitoring

The cell-based sensors Elisabeth Smela develops allow testing and 24-7 monitoring of a broad array of nanoparticles in a massively parallel fashion. Micro-fluidic biomaterial inserted on an electronic chip – a biochip – provides information used to control micro-electrical mechanical systems, or MEMS. By placing individual cells in nano-scale chambers connected by ultra-fine tunnels, Smela can "read" biochemical messages the cell releases into the tunnel fluid when it receives specific stimuli.

This is a vast improvement over current time-consuming and expensive cell culture methods, which require incubation periods between tests and examine a limited number of reactions to a limited number of substances. Cell-based sensors not only monitor reactions to nanoparticles in real time, but do so all the time, with a wide variety of sensors and on a great number of chips simultaneously. This ability to test in whole body environments is crucial for understanding cell differentiation, developing pathogen identification methods, and improving sensor technologies in general.

Smela's long-term research interests include toxicity testing and expanding cell-based sensors for other health applications such as "electronic noses." These devices would combine canine olfactory neurons and chip technology, creating extremely perceptive "noses" for hazard sensing.

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Gary Rubloff collaborates with Smela and Zachariah to improve biochip technology for capturing and characterizing cells in active micro-fluidic environments. Like tiny lab cages, these networks of chambers "capture" cells. Rubloff transports oxygen, nutrients, and waste to and from the cells in order to maintain their health, and he then exposes them to various stimulants. The diagnostic techniques he develops allow real-time monitoring of the cells' responses.

This research provides key information for developing nano-based diagnostics, facilitates toxicological testing, and improves the efficacy and cost efficiency of clinical trials. It is also leading to the discovery of new drugs that prevent bacteria from forming antibiotic resistance – by manipulating cell sensing, these compounds simply shut down the growth of bacteria prior to pathogenicity.

The University's Nanocenter can fabricate the precisely sized and structured nanoparticles needed for controlled tests such as these. Rubloff plans to extend the technology for use in cell-based detection of biological and chemical agents.

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