

## **Nanotechnology to the Rescue: A chemical free, antimicrobial platform using Engineered Water Nanostructures**

**Philip Demokritou, PhD**  
**Director, Harvard-NIEHS Nanosafety Research Center**  
**Director, Center for Nanotechnology and Nanotoxicology**  
**Harvard T. H. Chan School of Public Health**  
**Co-Editor in Chief, Nano-IMPACT**

### **ABSTRACT**

Despite advances in public health, infectious diseases continue to affect millions of people, often with serious outcomes. The toll of airborne infectious disease is further complicated through the evolution of antibiotic-resistant bacteria, while the constant antigenic shift of influenza viruses creates difficulties for vaccine development. Similarly, microbial contamination is a leading cause of foodborne illnesses and food waste in the US with the annual cost exceeding 15 billion USD. Control of these infections remains a challenge and currently relies on interventions that have significant shortcomings, including health risks. Air disinfection for the interruption of transmission relies on UV-A radiation, HEPA filtration and biocidal gasses while for food disinfection chemical and thermal methods are widely used and create many inefficiencies and environmental health implications. New, innovative, effective, low cost and most importantly chemical-free, 'green' technologies, possessing fewer drawbacks than the existing ones, are urgently in need in the battle against infections.

Recently, a novel nanotechnology-based, chemical free, antimicrobial platform was developed. It relies on the synthesis of Engineered Water Nanostructures (EWNS) using electrospray and ionization of water. These nano-structures possess unique physicochemical and biological properties and have been found to interact and inactivate pathogens through destruction of their cell membrane, on surfaces and in the air. The synthesis and property characterization of EWNS will be presented. Their effectiveness on inactivation of microorganisms on surfaces and air will also be discussed. Applications across the Farm-to-Fork chain for enhanced food safety and quality assurance will be presented. (Disclaimer: Funding for the development and characterization of EWNS platform was provided by the US National Institutes of Health (NIH) and United States Department of Agriculture (USDA))

**Philip Demokritou, PhD- Biosketch:** Dr Demokritou's research interests are primarily in the areas of nano-aerosol science and technology with emphasis on the elucidation of particle health effects. His particle research spans across the exposure- disease continuum and includes the development of personal PM monitoring systems for use in exposure assessment and epidemiological studies, methods for the physico-chemical and in-vitro/in-vivo toxicological characterization of nanoparticles. Such novel methods linking particle exposures to toxicology and adverse health effects have been widely used by scientists in the field and also adopted as reference methods by scientists at US EPA, Environment Canada and other PM exposure assessors around the world and helped in advancing the field of particle health effect research. His current research focuses on nanosafety and nano-bio interactions related to engineered nanomaterials (ENMs) and the role of ENM structure on bioactivity. His nanosafety research has involved development of in-vitro screening approaches for nano-specific effects (DNA damage, epigenetics, translocation of ENMs across biological barriers, etc), "safer by design" approaches for families of ENMs, development of advanced tools and framework approaches for in-vitro/in-vivo dosimetry, life cycle specific risk assessment studies for nano-enabled products (NEPs) and environmental nanotechnology applications for pathogen inactivation. Dr Demokritou is currently the Director of two interdisciplinary research Centers at Harvard University: Harvard-NIEHS Nanosafety Research Center and the Center for Nanotechnology and Nanotoxicology at ([www.hsph.harvard.edu/nano](http://www.hsph.harvard.edu/nano)). He served as a co-PI of the Harvard-EPA PM Health Effect Center (1999-2010, US EPA star grant) and as the Director of Harvard-Cyprus International Institute for the Environment and Public Health from 2005-2008 and participated in the development of graduate level degree programs in the area of Environmental Health. He served as PI, co-PI or co-investigator on several grants funded by NIH, EPA, NIOSH, NSF, USDA/NIFA, CPSC and EU research framework (FP7). He holds 6 international/US patents and inventions. He is a co-author of two books, numerous book chapters and hundreds of articles in leading journals and conference proceedings in nanoscience, particle health effect and aerosol engineering fields. Dr. Demokritou's innovative research was highlighted in major mainstream media and online magazines including articles published in the Economist, NanoWerk, Chemistry world, The Scientist, ACS C&En News, MIT News, Harvard Gazette, NBR news. Dr Demokritou is currently an Associate Professor at Harvard School of Public and a founding co-Editor in Chief of NanoImpact, a journal that focuses on all aspects of nanosafety research (Elsevier)