Detection, characterization, and toxicological assessment of nano- and other advanced materials in consumer products: Progress, challenges, needs and opportunities

Dhimiter Bello, ScD, MSc
Dept. Biomedical and Nutritional Sciences, UMass Lowell, 883 Broadway Street, Lowell, MA, USA
Dhimiter_Bello@uml.edu

Abstract
Many engineered nano/materials (ENMs) eventually reach large scale production and routine use in consumer goods, foods, and personal care products. Millions of workers and consumers are being exposed on a regular basis to these ENMs across the life cycle of nano-enabled products, from synthesis to end-of-life. Assessing toxicological properties of these ENMs in complex matrixes, under realistic exposure scenarios to humans, present serious technical and methodological challenges related to nanoparticle detection in products and biological tissues, their quantitation, documentation of physio-chemical and morphological transformations that happen as part of the process, and biomonitoring, to name a few. Significant progress has been made in the past two decades in our collective understanding of the fundamental relationships between nanoparticle physio-chemical properties and nanoparticle biokinetics with mechanistic toxicology using raw or pristine materials. Progress in untangling these dose-effect relationships in humans for ENMs in complex product matrixes under mixed exposure scenarios in the real world has been notably slower. Major unmet challenges include determination of the more relevant dose metric for health effects studies, the contribution of ENMs relative to matrix components and incidental nanoparticles on adverse health effects, interactive/catalytic effects of ENMs with the matrix components, and lack of ENM-specific biomarkers of exposure (especially for carbonaceous ENMs) or effects.
The presentation will start with a brief historical perspective of major developments in the field of nanotoxicology over the last two decades and use select case studies to illustrate the challenges and the lessons learned. One such case study involves ENMs incorporated in toner-based laser printing and photocopying and human health. Through a comprehensive case series of 40 studies that were developed over a decade of interdisciplinary and multi-PI research efforts, we offers insights into some of the unique ENM-mediated phenomena on chemical composition of laser printer emissions, dose metrics and their toxicology on the respiratory and cardiovascular systems, inflammation and oxidative stress, immune system, and airway microbiome remodeling, across multiple testing platforms - cell co-cultures, animal inhalation studies, and human molecular epidemiology investigations. A second case study involves ingested ENMs (specifically titanium dioxide E171) in foods and gastrointestinal health (such as barrier integrity and inflammation). The presentation will conclude with (i) how such research experiences can inform and guide our collective scientific approaches and responses to the studying of applications and implications of the new generation of emerging advanced materials and technologies for solving challenging societal and security challenges; and (ii) how the nano scientists can work closer with nanotoxicologists to develop new technology to meet unique sensing and metrology needs for the nanotoxicology community.