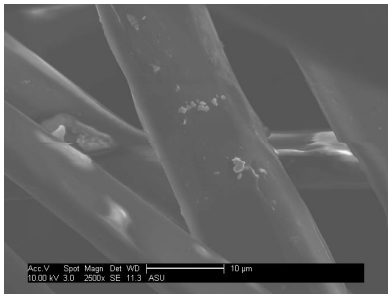
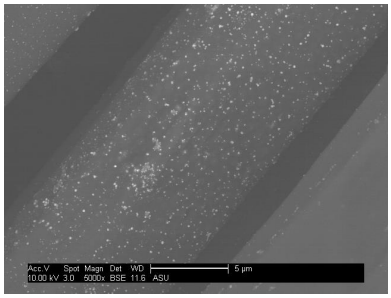
NCCLCs: Material Life Cycle of Nanomaterial





Overview. Nano-enabled products that incorporate engineered nanomaterials (NMs) will have transformative benefits to individuals and society. The safety of such products to humans or the environment, however, remains poorly understood and creates tremendous uncertainty for industry and risk managers. As a result, scientists developing new nano-enabled products have little information on the potential life cycle implications of their designs, leading to critical data gaps regarding possible NM exposures and hazards (e.g., release rates, toxicity). To address knowledge gaps that prevent the safe development of nano-enabled products, this project fuses the interdisciplinary expertise of chemists, toxicologists, scientists, engineers, and social scientists in NM fabrication, analytics, product release testing, exposure forecasting, high throughput toxicity screening, and life cycle evaluation to create a research network on the life cycle of nanomaterials (**LCnano**). We hypothesize that the desirable physicochemical properties that create unique NM functionality can also influence inherent hazards and potential exposure routes. LCnano's overarching goal is to elucidate NM property-exposure and property-hazard relationships from a life cycle perspective and provide predictive models for unintended implications of NMs that will improve design of safe nano-enabled products and processes. A systematic evaluation of four product lines expected to have variable NM release rates (e.g., dispersed in liquids, dispersed in foods, embedded in polymers, and attached to textiles) is planned, focusing on four high-product volume NMs (TiO_2, SiO_2, Ag_0, MWCNT), each of which exhibit unique properties and properties similar to other emerging NMs. Experiments using model and commercial nano-enabled products will evaluate yield and byproducts during NM synthesis and, using novel nanometrology, examine release rates and characteristics.

Intellectual Merit. LCnano will be transformative in its management of trade-offs between intended function of NMs in products and risks to humans and the environment. A dynamic life cycle assessment knowledge-network (*dLCA*) is developed to address the current lack of consistent and integrated design-actionable information on the release, toxicity, and synthesis impacts of NMs from nano-enabled products. LCnano, in partnership with nanoHUB.org, will function with a backbone network topology organized around the *dLCA* structure, providing communications, operations, assessment, and research products, with connectivity to the broader nanoscience and stakeholder communities. LCnano will facilitate data mining, direct data collection, and development of mathematical models that account for uncertainty and for enabling NM release and risk profile forecasting. To inform risk managers, LCnano will employ high throughput functional assays to quantify material attributes that serve as proxies for short- and long-term risk (material exposure, hazard, reactivity, and distribution). To inform designers of nano-enabled products about tradeoffs between performance and risk, LCnano will develop material property-exposure and property-hazard relationships for identifying and subsequently minimizing risk for a wide array of existing products, helping ensure sustainable design of future, transformative nano-enabled products.

Broader Impacts. The impacts of LCnano are expected to (i) reduce uncertainty in risks from nano- enabled products for the public, manufacturing communities, and regulatory agencies, (ii) provide the framework for existing and future nano-enabled product designs that preserve commercial value while minimizing adverse environmental health and safety effects, (iii) train a diverse group of undergraduate, graduate, and post-doctoral scientists to work as a network and produce integrated research products, and (iv) educate the public on the importance of the life cycle perspective for maximizing the benefits of nano-enabled products. LCnano is a collaboration of academia, industry, and governmental labs for conducting research products, facilitating NM material acquisition, and providing opportunities for student internships. Signature achievements will be: student exposure into how science becomes policy through *Science Outside the Lab*; the development, testing, and deployment of museum educational programs through Nanoscale Informal Science Education Network (NISE Net); and the digital networking of scientists and citizen scientists through nanoHUB.