Fate, Transport, and Toxicity of Engineered Nanoparticles in the Atmosphere

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Introduce the research area and project objectives. Discuss methods employed, field of impact, collaborations and notable results.

Nanomaterials represent a burgeoning field of technological innovation. With the onset of environmental release associated with nanomaterial manufacture and proliferation, the concomitant effects on atmospheric chemistry, impacts on air pollution formation and resulting human health remain unknown and polemic.

One of the fundamental hypotheses of this project is that nanoparticles can alter the atmospheric chemistry of the surrounding pollutants and secondary organic aerosols (SOA) that accumulate on nanoparticles. Major research activities include smog chamber experiments to assess the impact of nanoparticles on atmospheric chemistry and determine if they increase atmospheric secondary organic aerosol formation. Also major research activities are on the impact of toxicological methods used to determine health impacts.

Agglomeration of nanomaterials in biologically relevant media further complicates dosing in toxicological study. From a physicochemical standpoint, agglomeration status directly affects the size, stability, and concentration of nanoparticles delivered. However, the toxicological standpoint is concerned with the biological relevance of the agglomerated dose and its subsequent effect on biological endpoints. The main objectives of our toxicity directed research is to compare the effects of dispersion techniques on the physicochemical and toxicological dosimetry of TiO_2 (<50 nm) and NiO (<20 nm) nanoparticles. We chose several methods described in the literature: Three media were prepared: F12K /10% FBS/1% P/S, F12K/0.1% Pluronic F68 nonionic surfactant/1% P/S, and F12K/0.01% DPPC/0.6 mg/mL BSA/1% P/S with varying concentrations of -TiO_2 and NiO nanoparticles. Physicochemical and toxicological effects were analyzed with dynamic light scattering (DLS), ICP-MS, DTT assay, and stimulation of A549 cells with nanoparticles for 4 and 24 hours followed by analysis of inflammatory and oxidative stress markers. The results: DLS confirmed that F12K/10% FBS/1% P/S de-agglomerated the nanoparticles better than the other two media with an average diameter <100nm and ICP-MS revealed that the concentrations delivered were proportional to the calculated value of the serial dilution. DTT analysis indicated that ROS generation shows a dose-response relationship that can be affected by particle agglomeration. RT-PCR at 4 and 24 hours indicated that inflammatory markers, were most strongly induced by lower concentrations of NiO, while higher concentrations indicated higher response to ROS. Our conclusions show that dispersion media physicochemical properties affect toxicological endpoints. We have found that the primary technique, resuspension of previously collected nanoparticles is flawed and gives highly variable toxicology results. Our data show that dispersion media differentially affect physicochemical properties and toxicological endpoints. Therefore, we conclude that *in vitro* nanotoxicology models that use re-suspension methods of exposure yield inconsistent biological results due to physicochemical variation of particle characteristics and transport processes. This is important because it is the most commonly used approach to assess the toxicity of nanoparticles.

A specific objective was to conduct smog chamber experiments comparing nanoparticles (TiO2) with ammonium sulfate as seed aerosols on photochemistry using complex urban-like mixtures and components. Smog chamber experiments to test for potential atmospheric effects show that TiO2 nanoparticles can dramatically increase the rate of atmospheric oxidation of NO to NO2 and generation of SOA from hydrocarbons like Toluene. Photosensitized OH formation from the surfaces of TiO2 is believed to be responsible for the increased rate of conversion of NO to NO2. If photosensitized OH from TiO2 nano aerosols is being generate, this may greatly impact the levels of secondary organic aerosols compared to ambient seed particles

References

[1] For further information about this project email **<ilona_jaspers@med.unc.edu; richkamens@gmail.com; ken_sexton@unc.edu>**

[2] A Comparison of Three Dispersion Media on the Physicochemical and Toxicological Behavior of TiO2 and NiO Nanoparticles, Erika Gutierrez[1], Richard Kamens[1], Michael Tolocka[2], Kenneth Sexton[1], Ilona Jaspers[3*] 1Department of Environmental Sciences and Engineering, Gillings School of Global Public Health 2Department of Chemistry, 3Center for Environmental Medicine, Asthma, and Lung Biology, School of Medicine, University of North Carolina-Chapel Hill, Chapel Hill, North Carolina, USA, submitted to Nanotoxicology October 2013.

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