US EPA ARCHIVE DOCUMENT

Impacts of Manufactured Nanomaterials on Human Health and the Environment – A Focus on Nanoparticulate Aerosol and Atmospherically Processed Nanoparticulate Aerosol

Vicki H. Grassian

Departments of Chemistry and

Chemical and Biochemical Engineering

University of Iowa

Nanoparticles and Air Quality

Heterogeneous Atmospheric Chemistry: Surface Reactions of Nanoparticulate Tropospheric Aerosol (dust, soot…)

Environmental Impacts of Manufactured Nanoparticles as Tropospheric Aerosol

Nanocrystalline Zeolites in Environmental Remediation

Background - Implications

- Nanoscience and nanotechnology offer new opportunities for making superior materials for use in environmental, industrial and health applications.

- It is clear from some of the recent literature that the full impact, or even partial impact, of manufactured nanomaterials on human health and the environment has yet to be fully explored.

- Manufactured nanoparticles may become suspended in air during production, distribution, use and disposal (life cycle). Therefore, manufactured nanoparticles can become a component of the tropospheric aerosol and thus the air we breath.
  - Single particle mass spectrometers have detected ultrafine SiO_2 particles (10 nm) outside of Houston

Phared, Rhoads, Johnston and Wexler, JGR Atmospheres ***2003****,108, 8420 doi:10.1029/2001JD001212*

Objectives of Proposed Research

- fully characterize a variety of manufactured nanomaterials in terms of their size, shape, bulk and surface properties (metal nanoparticles, oxide nanoparticles, semiconductor nanoparticles) ;

- determine if engineered nanomaterials are particularly deleterious to health compared to particles from combustion processes (accidental nanoparticles) that have been more extensively studied;

- evaluate the relative health effects caused by different surface coatings on the nanoparticle.

Hypotheses of Proposed Research

The first hypothesis of the proposed project is that manufactured nanomaterials (engineered nanoparticles) because of their small size and chemical compositions may be more toxic than other anthropogenic ultrafine particles currently present in the troposphere from combustion processes (accidental nanoparticles).

To test this hypothesis the following experiments will be completed:

-Perform a series of inhalation toxicology experiments on well characterized manufactured nanoparticles;

-Compare results to similar inhalation toxicology studies on ultrafine particles present in the atmosphere from combustion processes.

Hypotheses of Proposed Research -cont

The second hypothesis of the proposed project is that the toxicity of manufactured nanomaterials, due their high surfaces areas, the methods in which they are made and because once in the atmosphere will become coated, may change as a result of the surface coating.

To test this hypothesis the following experiments will be performed:

-Perform a series of inhalation toxicology experiments on particles with different surface coatings due to the manufacturing process;
-Perform a series of inhalation toxicology experiments on particles with different surface coatings to simulate atmospheric processing or aging in the atmosphere;
-Determine from these experiments if surface coatings can change the toxicity of manufactured nanoparticulate aerosol.

Approach

Investigate the Impacts of Manufactured Nanomaterials on Human Health and the Environment – A Focus on Nanoparticulate Aerosol and Atmospherically Processed Nanoparticulate Aerosol

Part A

Sources and Characterization of Nanoparticles Prior to Aerosol Generation

Characterization and Modification of Surface Coatings

Part B

Aerosol generation

Inhalation Exposure Studies

Aerosol Characterization

Part C

Toxicology Analysis

Statistical Analysis

Multi-Investigator Research Team

Research Team to Investigate the Impacts of Manufactured Nanomaterials on Human Health and the Environment – A Focus on Nanoparticulate Aerosol and Atmospherically Processed Nanoparticulate Aerosol

Grassian

-purchase and fully characterize nanoparticles prior to aerosol generation
-prepare and fully characterize surface coatings

Chemistry and Chemical and Biochemical Engineering

O'Shaughnessy

-aerosol generation
-animal exposure studies
-aerosol characterization

Environmental and Occupational Health and Environmental Engineering

Thorne

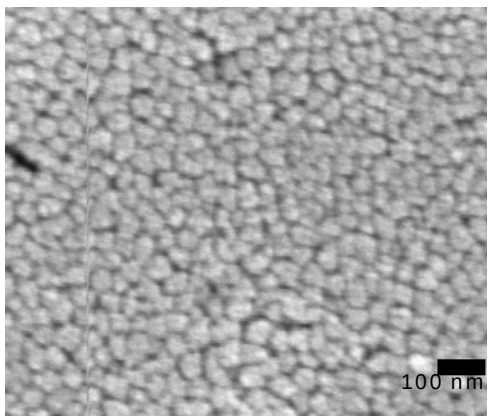
-inhalation toxicology study design
- analysis of health outcomes from exposures

Environmental and Occupational Health

Equipment and Facilities Available for the Proposed Studies

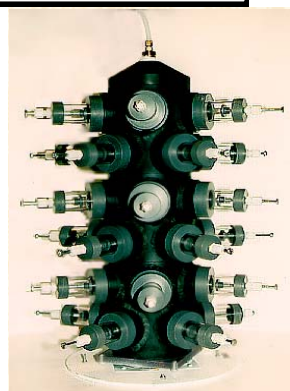
Particle Characterizaton	*Aerosol Generation and Exposure*	*Animal Toxicology Analyses*
-X-Ray powder diffraction -FT-IR spectrometers with ATR attachments for surface spectroscopy -X-Ray Photoelectron Spectroscopy -Auger Electron Spectroscopy -SEM and TEM -Automated BET apparatus -Scanning Mobility Particle Sizer with Nano and Long DMA options (TSI-3936NL25)	- ball mill - Wright dust feed - fluidized bed generator - Collison nebulizer - inhalation exposure chambers - aerosol photometers	- necropsy equipment - cytokine assays - microscopes for cell counting - rodent housing rooms

SEM Images of 20 nm silicalite



Inhalation Exposure Chambers

Whole-body inhalation exposure chamber.



Nose-only inhalation exposure chamber.

Planned Experiments and Timeline

Activity	June '04 - May '05	June '05 - May '06	June '06 - May '07
1. Purchase and Characterize Nano materials and prepare carbonaceous aerosol for comparison purposes	xxxxxxxxxxxxxxxx		
2. Aerosol Characterization and Exposure Studies (including one s on carbonaceous aerosol)	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx		
		xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	
			xxxxxxxxxxxxxxxxxxxxxxxxxxxx

Expected Outcomes

•It is expected that these studies will help answer questions as to the potential impact of manufactured nanomaterials (as aerosol) on human health as there is clearly a lack of information in this regard.

•Two important factors of the proposed activities are the comparison of the potential health effects of manufactured nanomaterials to other anthropogenic sources of ultrafine particles from combustion processes and the effect of surface coatings, from manufacturing and atmospheric processing, on the toxicity of these particles.

-The comparison of manufactured nanoparticulate aerosol to nanoparticulate aerosol from combustion processes can provide important information as there have been many more studies on ultrafine particles from combustion processes. Health effects of ultrafine particles from combustion processes are better understood and may provide some benchmarks and help frame researchers thinking about manufactured nanoparticulate aerosol.

-The effect of surface coatings in these studies will provide information that may be beneficial to understanding the health effects of particulate matter in general in the atmosphere. Because of the extremely high surface areas of nanoparticles (>500 m^2/g), any effects due to surface coatings may become even more evident.