Modifications of Nanoparticles in the Environment: Implications for Bioavailability

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Nanomaterials in the Environment

- Entry
- Aging
- Fate
- Surface Modification
- Bioavailability
Release and Exposure of Nanoparticles

Human Exposure

Ecological Exposure

NM Synthesis

Occupational

Specific

General

Water, Soil, Air …

Feedstock

Product

Product manufacturer

Consumers

Attrition

Disposal

Environment

Unintentional spill/ Intentional Application

Kathleen Sellers, AMEC Inc.
Nanomaterials in the Environment:

- Accidental Spill
- Direct Application
- Product Use
- Waste Discharge
- Leaching from Landfills
- Product Degradation
Nanomaterials in the Environment: 
AGING

- Degradation and Alteration of NP
Nanomaterials in the Environment: AGING

Degradation and Alteration of NP

50 nm

AIOH3

Polydimethylsiloxane

H2O, pH = 5, Low Ionic Strength <3 hours

Auffan, et al. 2010 ES&T 44(2689-2694)

TiO2

T-lite SF Used in cosmetics

10 nm
Nanomaterials in the Environment: AGING

Degradation and Alteration of NP

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AIOH3

Polydimethylsiloxane

H2O, pH = 5, Low Ionic Strength < 3 hours

90% of Si in organic layer lost; Surface layer oxidized

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50 nm

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Nanomaterials in the Environment: AGING
Nanomaterials in the Environment: FATE

Particulate and organic matter from coastal runoffs

Atmospheric inputs

Formation of aerosol, risk to seabirds and mammals

Concentration of NPs in the surface microlayer

Toxicity to embryos and plankton

Changes in temperature, ionic strength and natural organic matter with depth

Coastal sediments

Aggregation

Dilution and transport to open ocean

Toxicity to pelagic species

Accumulation of NPs or aggregates at interfaces?

Precipitation to ocean floor

Mobilisation of NPs by microbes

Toxicity to benthos

Ocean floor
Nanomaterials in the Environment:  
SURFACE MODIFICATION

- Abiotic
  - Phot0-oxidation/hydrolysis
  - Adsorption of natural organics
  - Adsorption of contaminants

- Biotic
  - Macromolecules
Surface Modification – NOM, MWNT
OH-SWNT sonicated in 8% FBS
Nanomaterials in the Environment: BIOAVAILABILITY

- Physical Factors
  - Size
  - Shape (including aspect ratio)

- Chemical Factors
  - Core Chemistry
  - Surface Chemistry
Legionella sp. Biofilm

Treatment: Control

Treatment: 3mg/L Au NP

4 nm citrate-coated spheres
Nanomaterials in the Environment: BIOAVAILABILITY

- Surface Modified Carbon Nanotubes
  - NOM
  - Fetal Bovine Serum

- Daphnia magna exposed to nanoparticle suspensions
  - Daphnids harvested, preserved, sectioned, stained
  - TEM of gut tracts
Control *Daphnia magna* gut tract

Ctrl103.tif
*D. magna* 96 hrs
Control Org
Print Mag: 2060x @ 51 mm
10:38 05/12/08

2 microns
HV=120kV
Direct Mag: 6000x
Clemson EM Center

Ctrl105.tif
*D. magna* 96 hrs
Control Org
Print Mag: 6890x @ 51 mm
10:43 05/12/08

500 nm
HV=120kV
Direct Mag: 20000x
Clemson EM Center
This area is electron dense and has a uniformed "direction" to it, meaning it is long and slender much like a tube(s) would be.
FBS coated OH-SWNT
Images taken with HD 2000