



Adsorption and Release of Contaminants onto Engineered Nanoparticles

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Start July 1, 2004

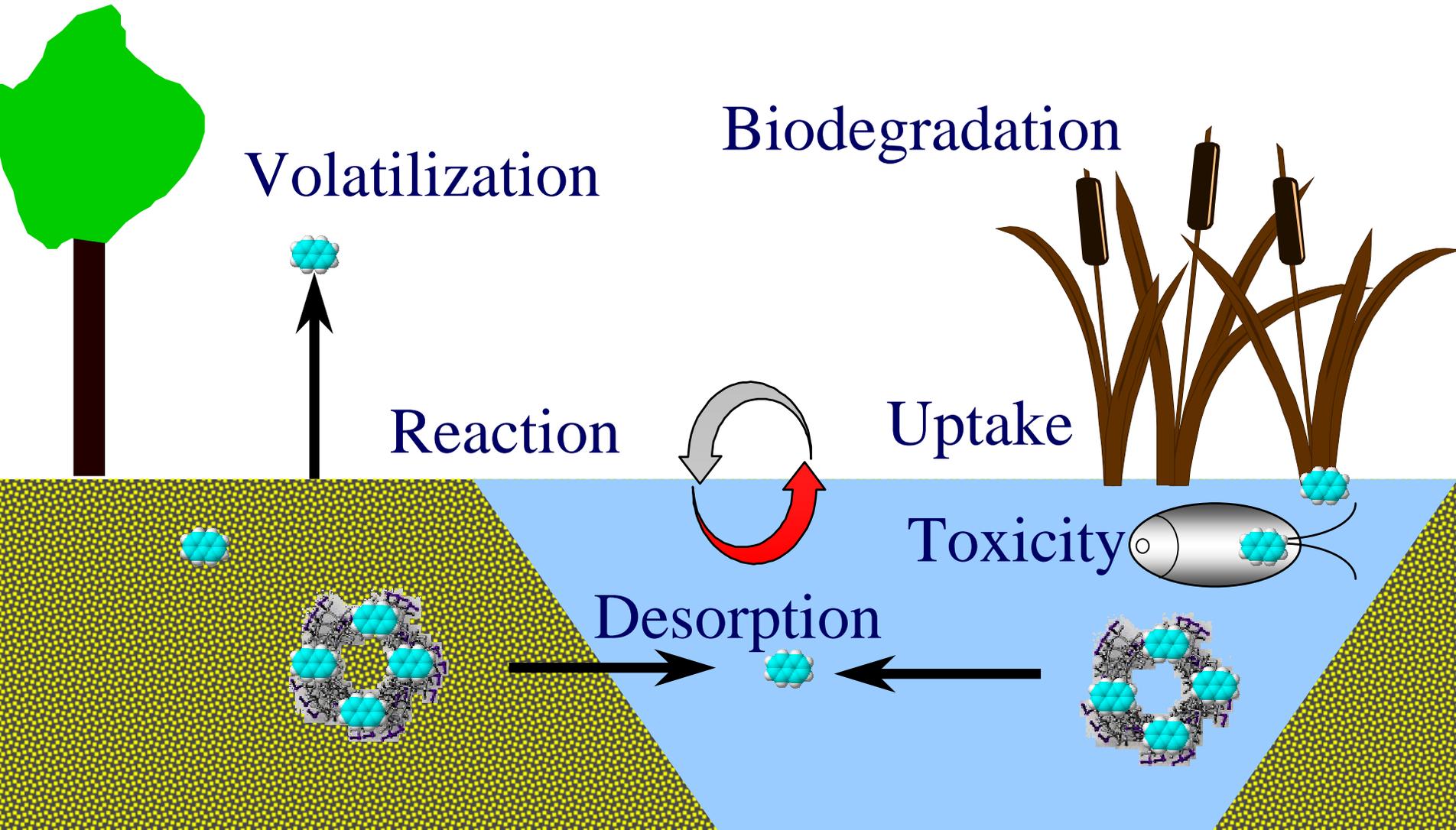


Objective and Benefit

- **Largely Avoidable:** The overarching goal of research proposed is to create the information needed to insure that avoidable deleterious outcomes of nanomaterial production and use never materialize.
- Develop the information needed to predict the risk of nanomaterials.
 - Adsorption and desorption of contaminants.
 - Impact of naturally occurring sorbents, NOM, heavy metals, surfactants.
 - Fate of nanoparticles in soil and water.

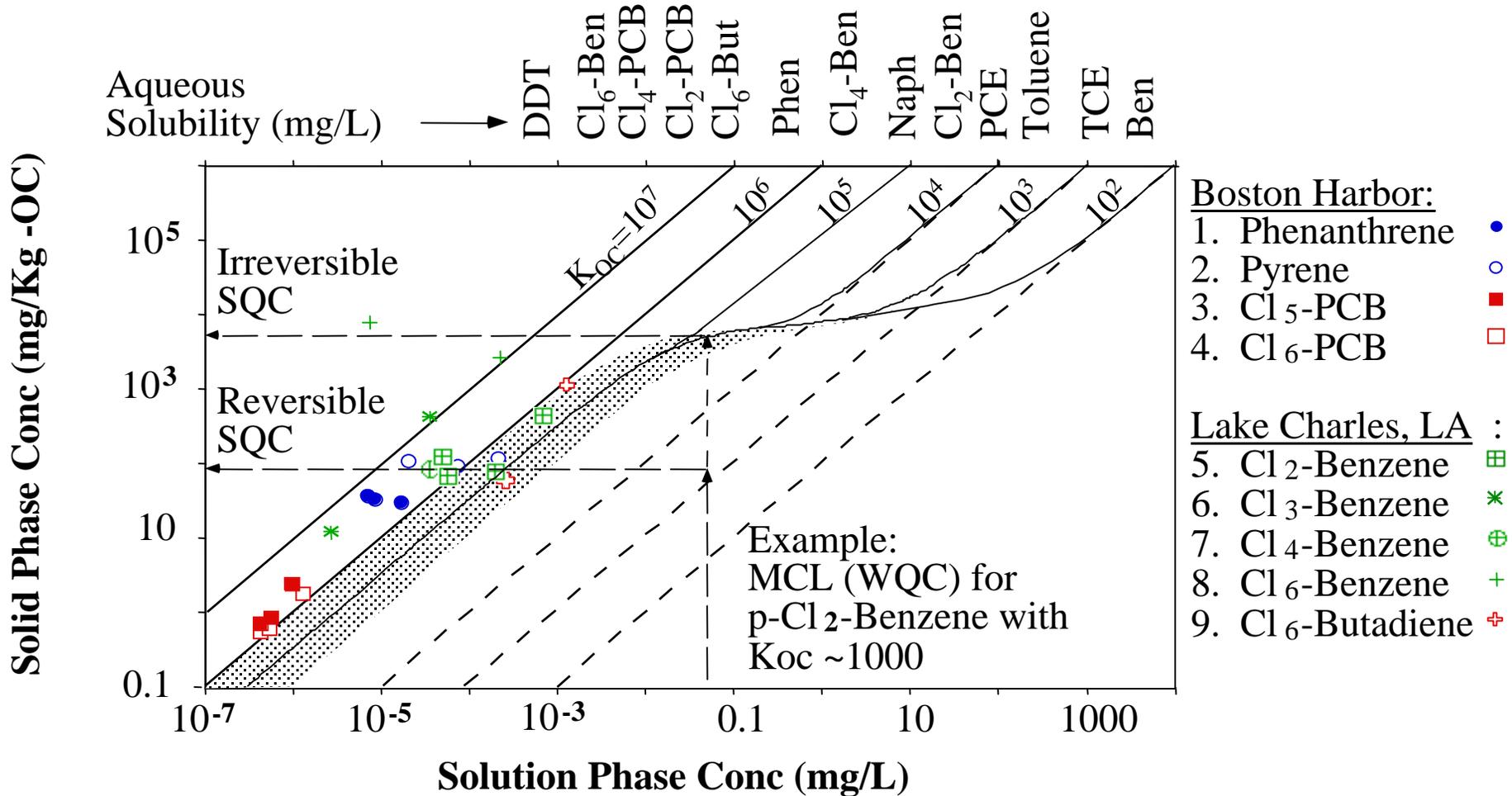


Adsorption/Desorption Hysteresis



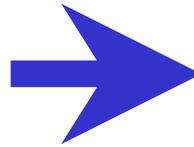
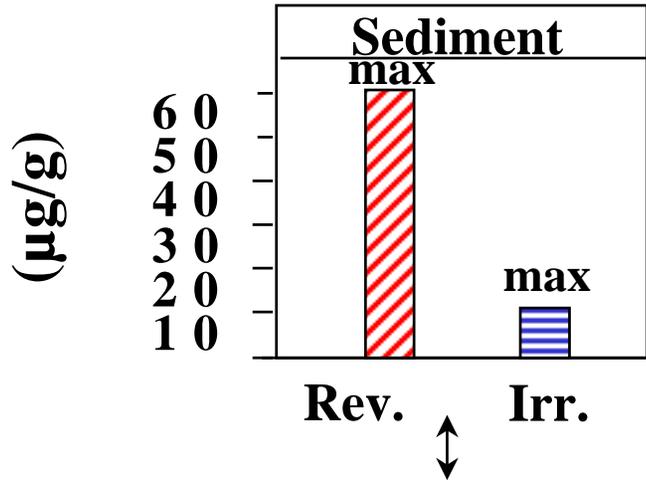


Adsorption/Desorption Hysteresis

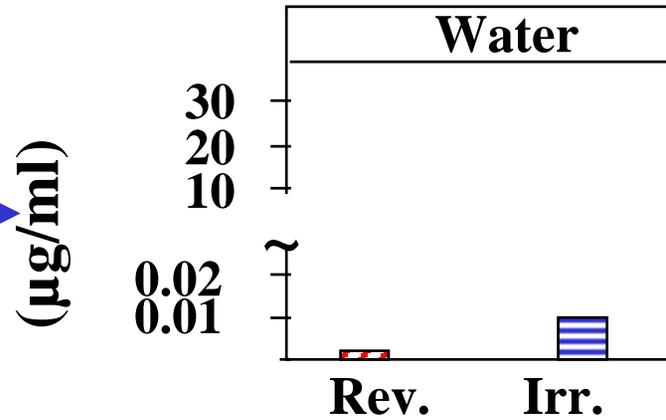
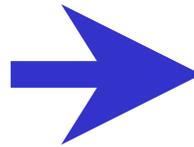
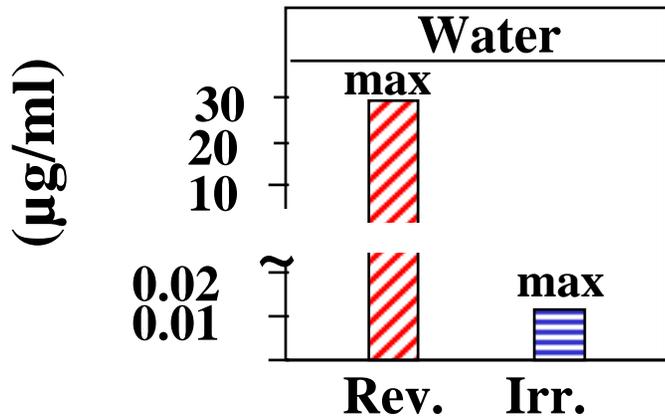
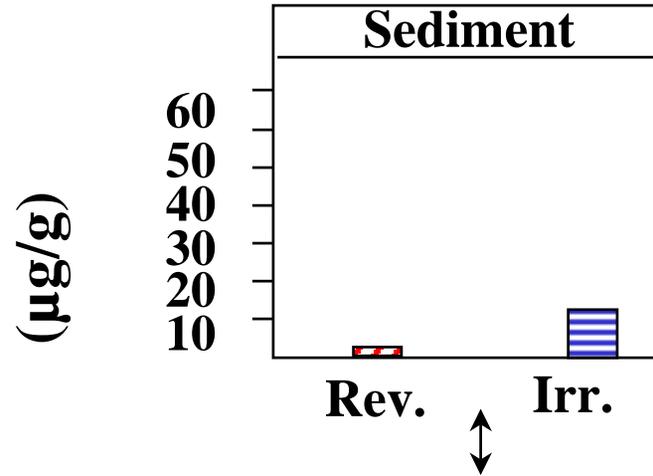




**"Unweathered,
non-remediated, or freshly
contaminated"**



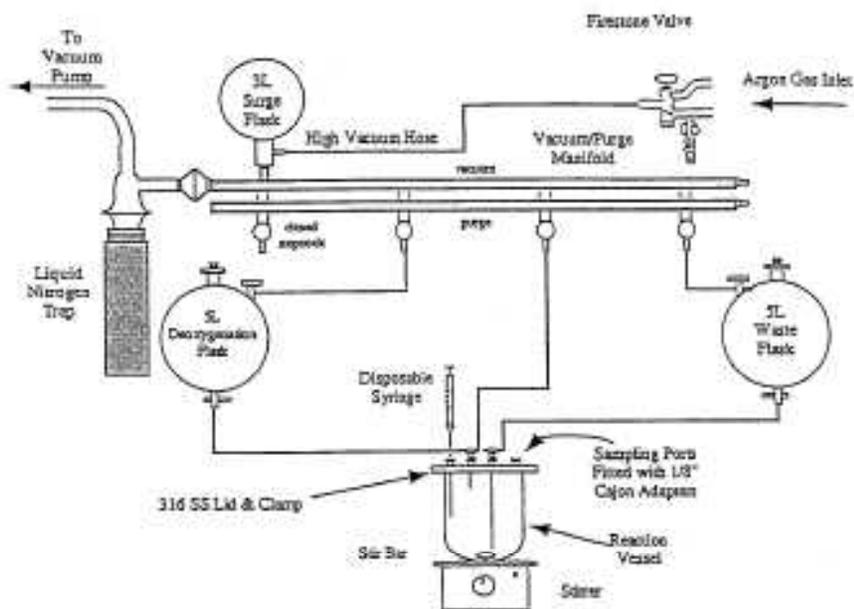
**"Weathered,
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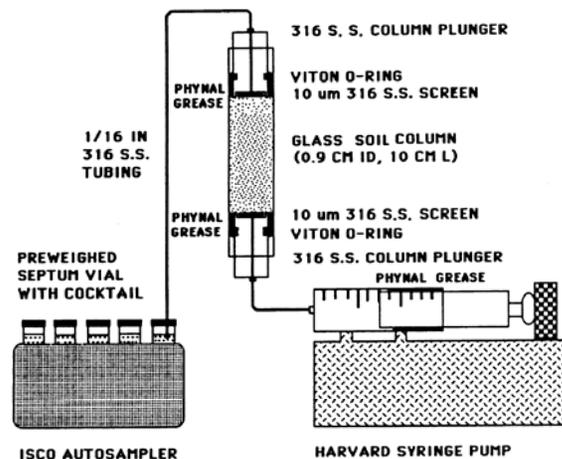


Approach and Methodology

Oxic/Anoxic Batch Apparatus



Column Apparatus





Adsorption of Organic Contaminants from Solution to C₆₀ Fullerene

Batch Adsorption/Desorption Study:



C₆₀ large aggregates



C₆₀ small aggregates

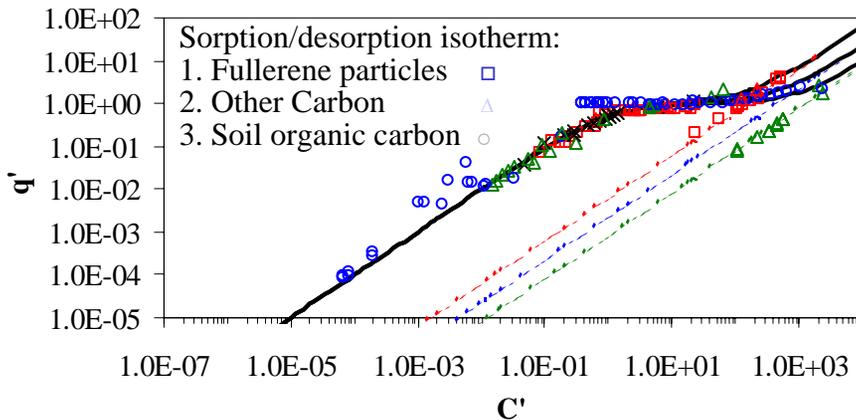


C₆₀ colloidal particles



Fate of Contaminants Adsorbed to Carbon Nano-Particles

Will the sorption and desorption of organic compounds to fullerene particles cause enhanced environmental contaminant transport?



Sorption of organic contaminants to fullerene particles is the same as to soil organic matter and to activated carbon. When fullerene particles migrate, contaminant transport will be enhanced.

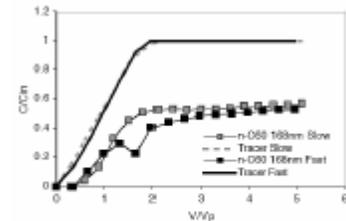
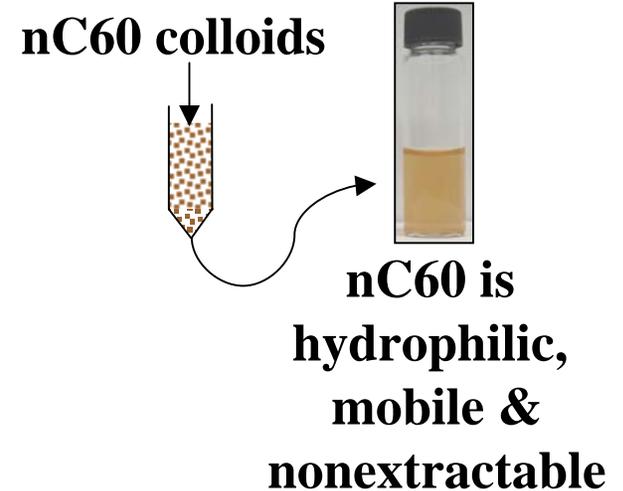
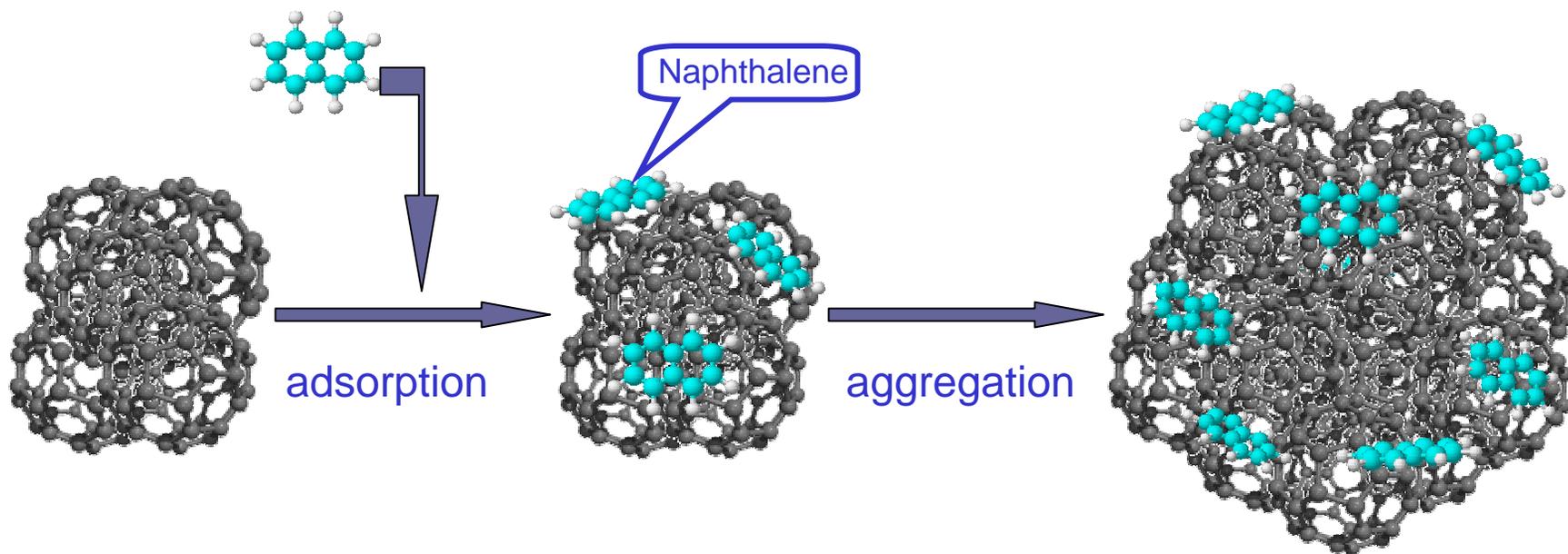


Figure 8.3.21: Breakthrough curves for nano- C_{60} aggregates at two Darcy velocities.

(Wiesner, 2004)



What Happened During Adsorption?



Small Fullerene Aggregates

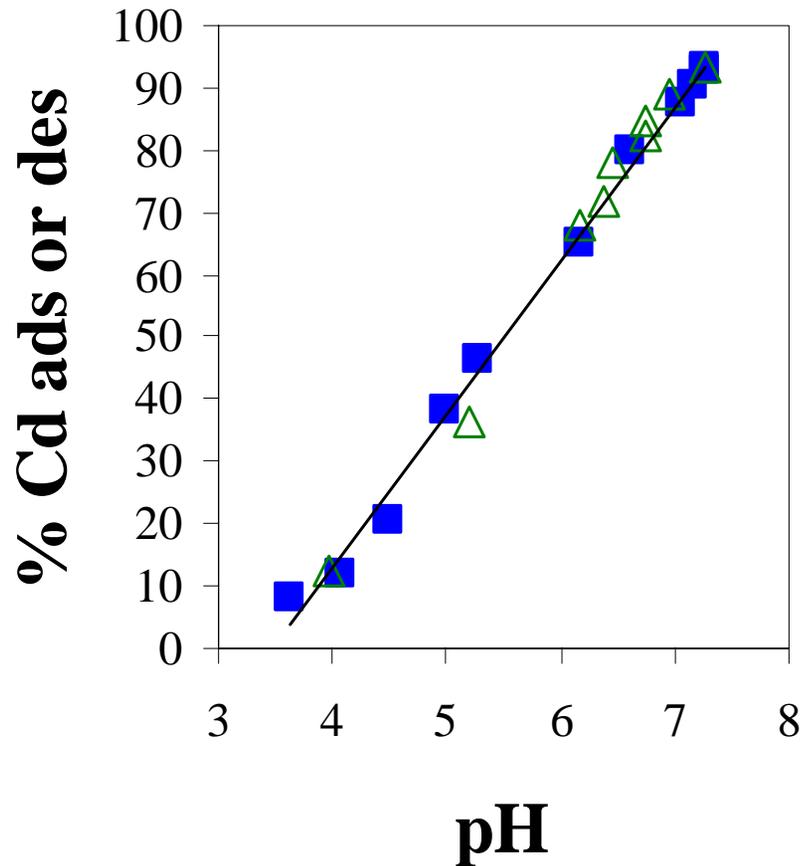
Naphthalene Adsorption

Clusters Aggregation & Naph. Entrapment

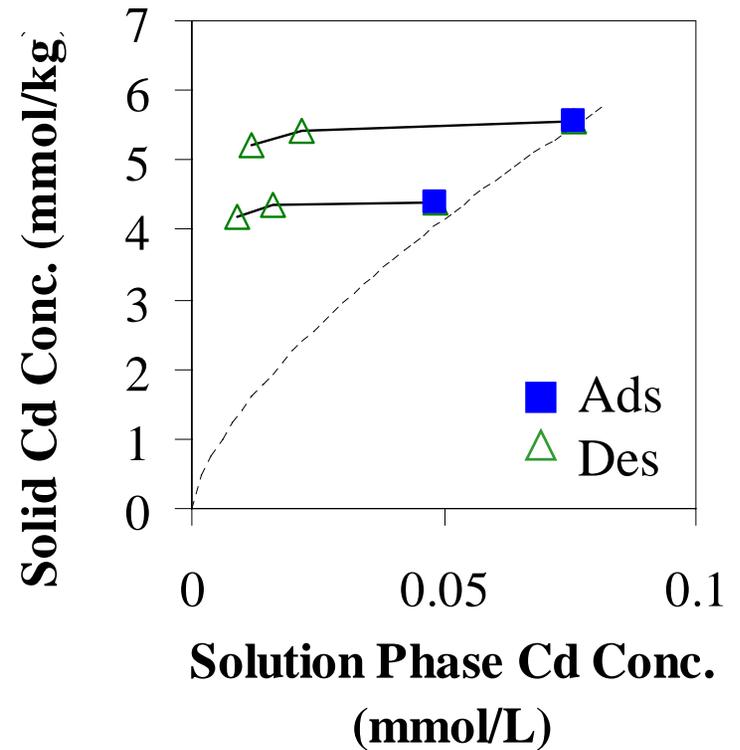


Adsorption/Desorption of Cd to Soil

Reversible

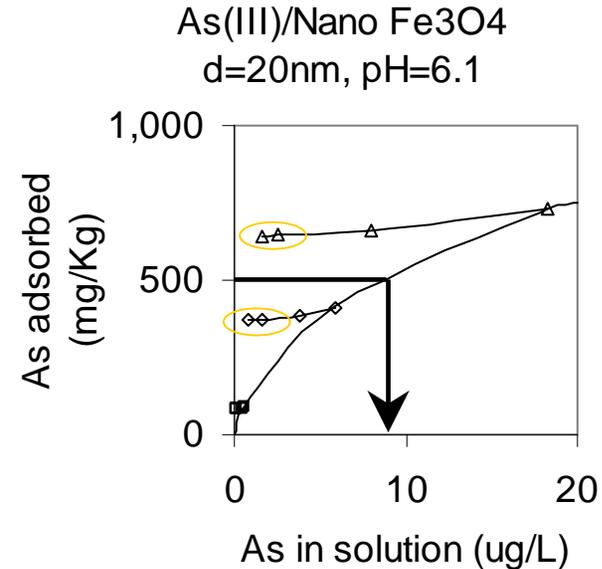
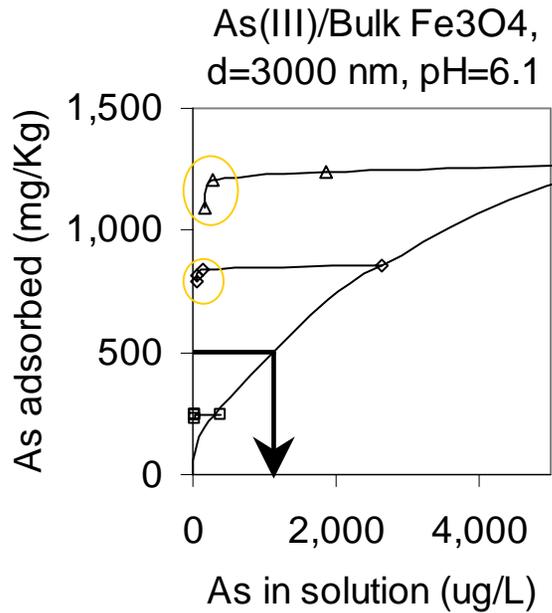


Irreversible





Sorption/Desorption of As to Magnetite

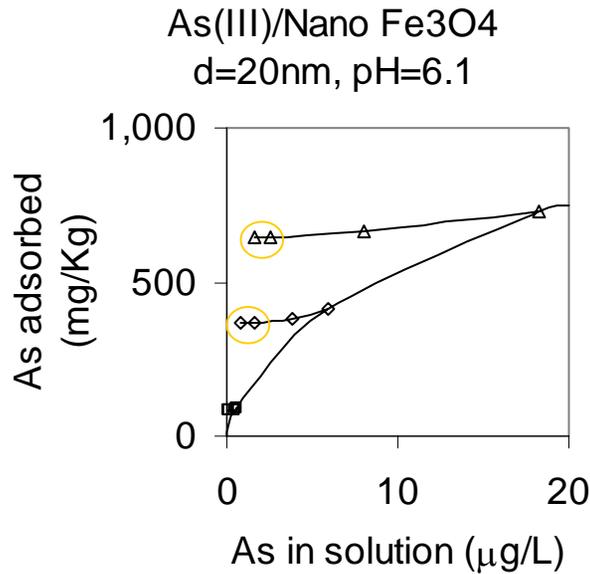


Nano Advantage: Disposal, no desorption bleed-off at low concentration.

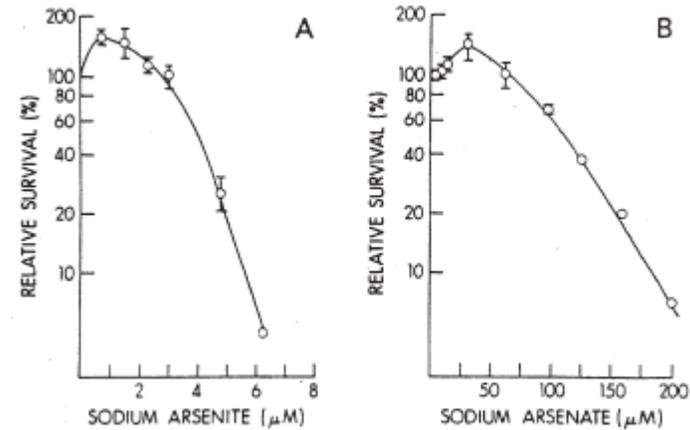
New Standards: USEPA (10 $\mu\text{g/L}$); State of N. J. (5 $\mu\text{g/L}$)



Hysteretic Desorption and Below Dose No Toxicity Effects



Hormesis Effect: No toxicity at low dose



(Calabres, 2003)

Hysteretic contaminant releases from sequestered nanoparticles may not harmful to the ecological environment.



Nano Advantages: Related to Contaminant Removal and Solids Disposal

- Between 10 and 30 times less solid to remove As (III/V) from water.
- Virtually no bleed-off: Once As (III/V) is adsorbed to nano-magnetite, desorption is orders of magnitude less than from bulk magnetite. This is an enormous disposal advantage.

Mass of Magnetic Needed For Similar Total As Removal



4 nm



20 nm



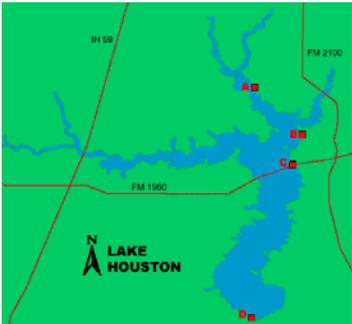
3000 nm



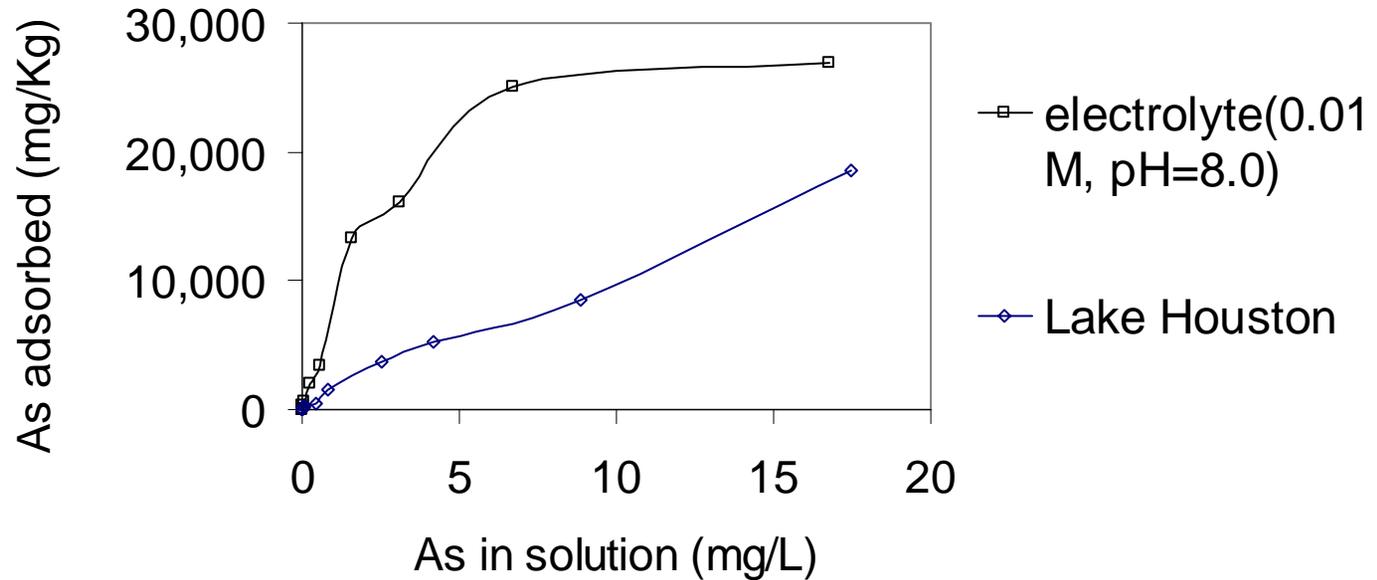


Competitive Adsorption - Natural Water

**Lake Houston:
Drinking
water reservoir
for Houston**



As (III) adsorption, 20 nm magnetite



Future research direction: Importance of competitive processes, organic matter, other heavy metals, silicates, and various forms of phosphates



Expected Benefits

- Provides the information needed to assess whether this risk is substantial for nanoparticles disposed of in groundwaters.
- Yields the necessary parameters to understand the fate of engineered nanoparticles in the environment.
- Yields the necessary parameters for future development of risk assessment of the engineered nanoparticles.