Nanoscale Sorbent for Water Treatment

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Mercury Challenges in the Environment: A Technical Summit
Vanderbilt University, Oct 22-23, 2009

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NEI Business

Use a platform of nanotechnology and chemistry

To produce Additives and Alternates for existing, high-volume products

Resulting in major benefits

For our Customers (in diverse industries)

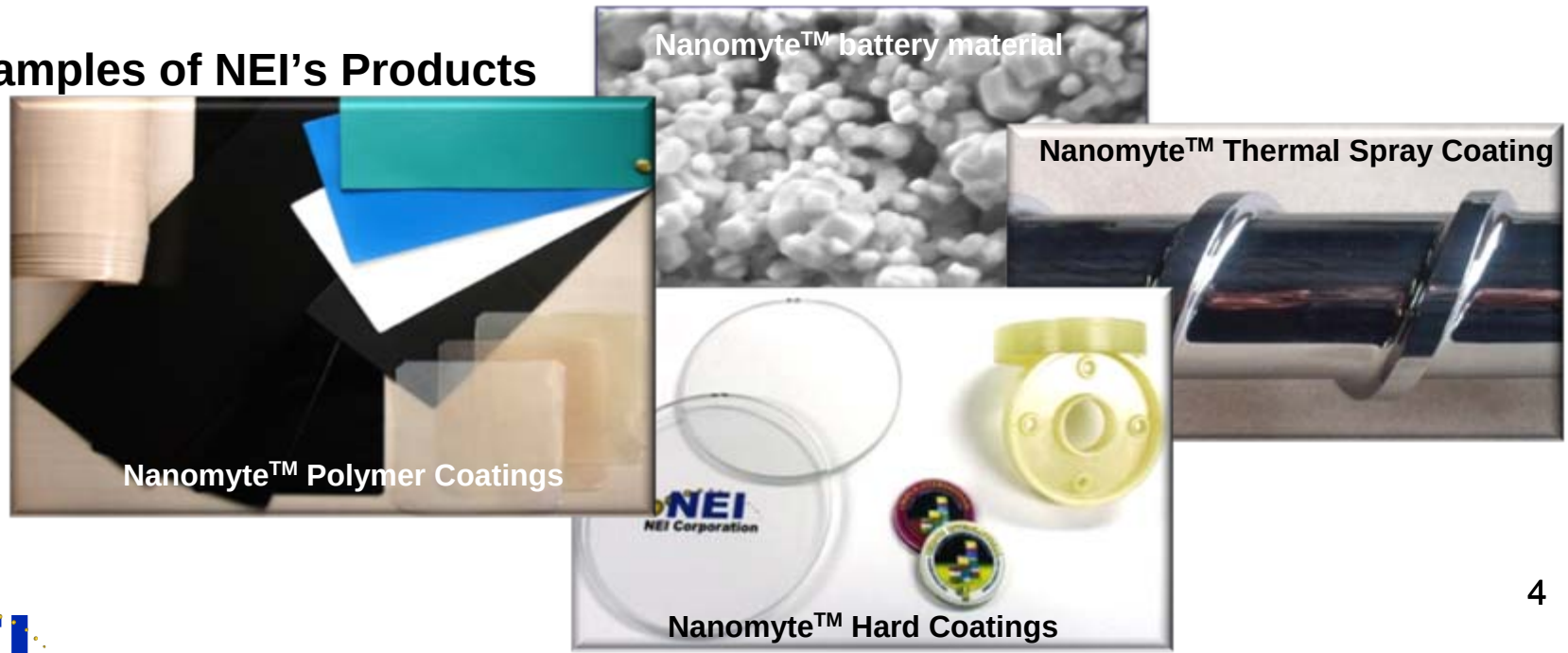
Key Highlights

- Incorporated in 1997; privately held
- Funded technology development through the SBIR/STTR programs
- Extensive network of collaborations
- 10,000 sq. ft. facility in NJ
- 40,000 sq. ft. facility in Kolkata, India
- Patents

NEI Core Competencies

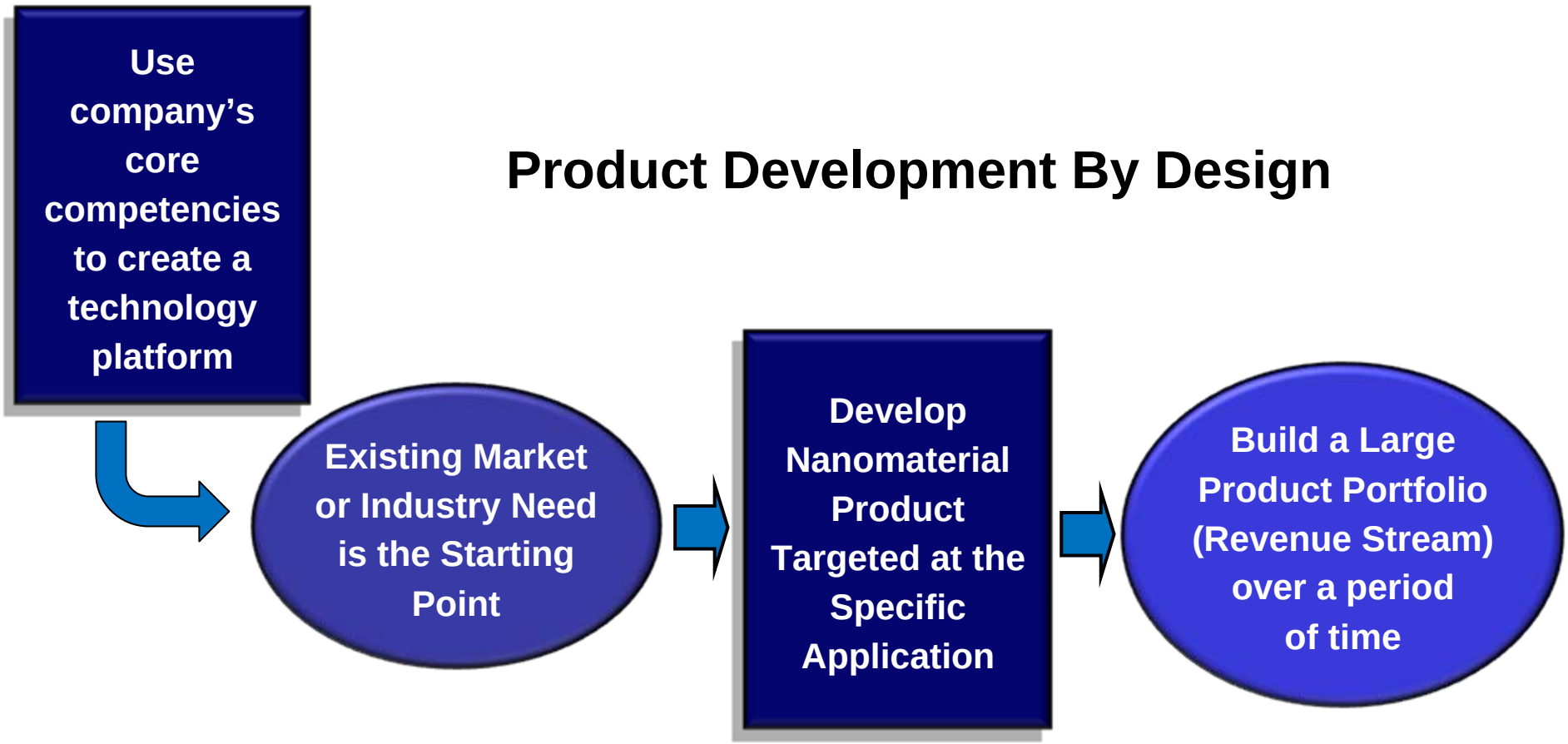
- **Incorporate Functional Nanomaterials in Advanced Materials and Devices**
- **Bridge the gap between Nanoscale Science and Commercial Applications**

Examples of NEI's Products



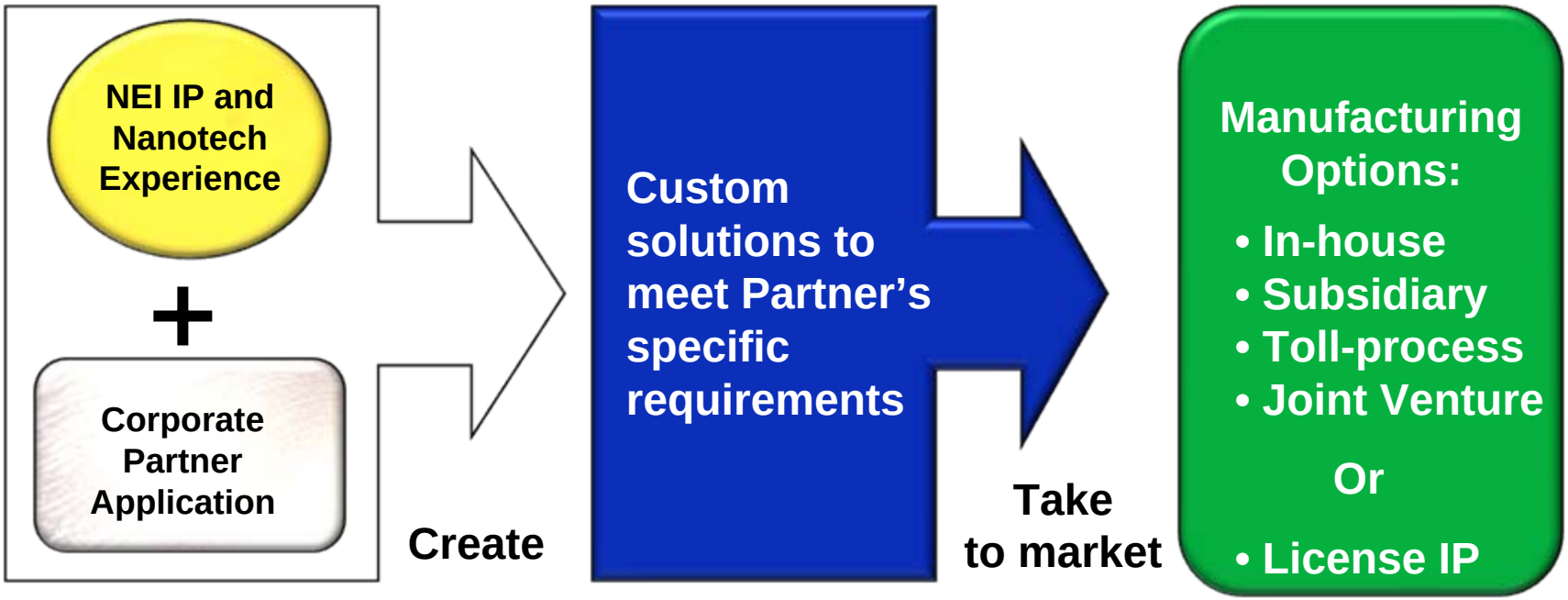
NEI Approach to Materials Development

Product Development By Design



Parallel ideas in 2008 DoE report "Nanomanufacturing for Energy Efficiency"

NEI's Business Model



One Customer at a time, one Application at a time!

Mercury capture method

Technologies applicable to Treatment of Mercury-contaminated Water*:

- Precipitation/Co-precipitation

- **Adsorption**

- Membrane Filtration

- Bioremediation

**EPA Report:*
Treatment technologies for mercury in soil, waste and water, August 2007

Opportunity for New Sorbent

- Sorbents generally are high surface area materials:
  - Activated carbon, amine-containing polymers, ion-exchange resins, modified clays, zeolities, modified silica and modified alumina

- The capacity and kinetics can be enhanced if the internal surface area is readily accessible to the mercury ions

- Sorbents need to have high selectivity, since competing ions such as Ca^{2+} and Mg^{2+}, Cu^{2+}, and dissolved solids are present in water

- Opportunity for a sorbent material where the internal surface area is highly accessible, and has selectivity towards mercury adsorption

Nanomyte™ Sorbent

- Being developed in two particle morphologies
  - Fabric filter
  - Cartridge and column

From micron size particles to millimeter sized pellets

NEI Nanomyte™ Sorbents

- Two types of sorbents are being developed
  - Differences in surface chemistry
  - Type I: Fast mercury adsorption kinetics
  - Type II: High mercury adsorption capacity
- Both types of sorbents can be aggregated to desired particle morphology
- The sorbent is for non-regenerable use
- Patent pending

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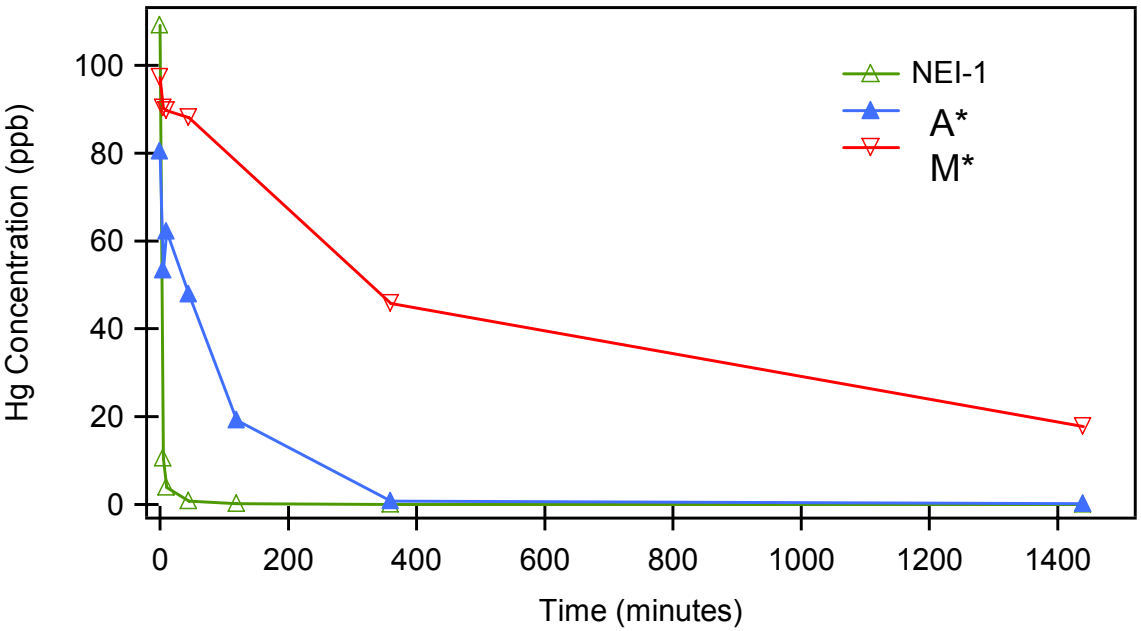
NEI Sorbent (Type I)

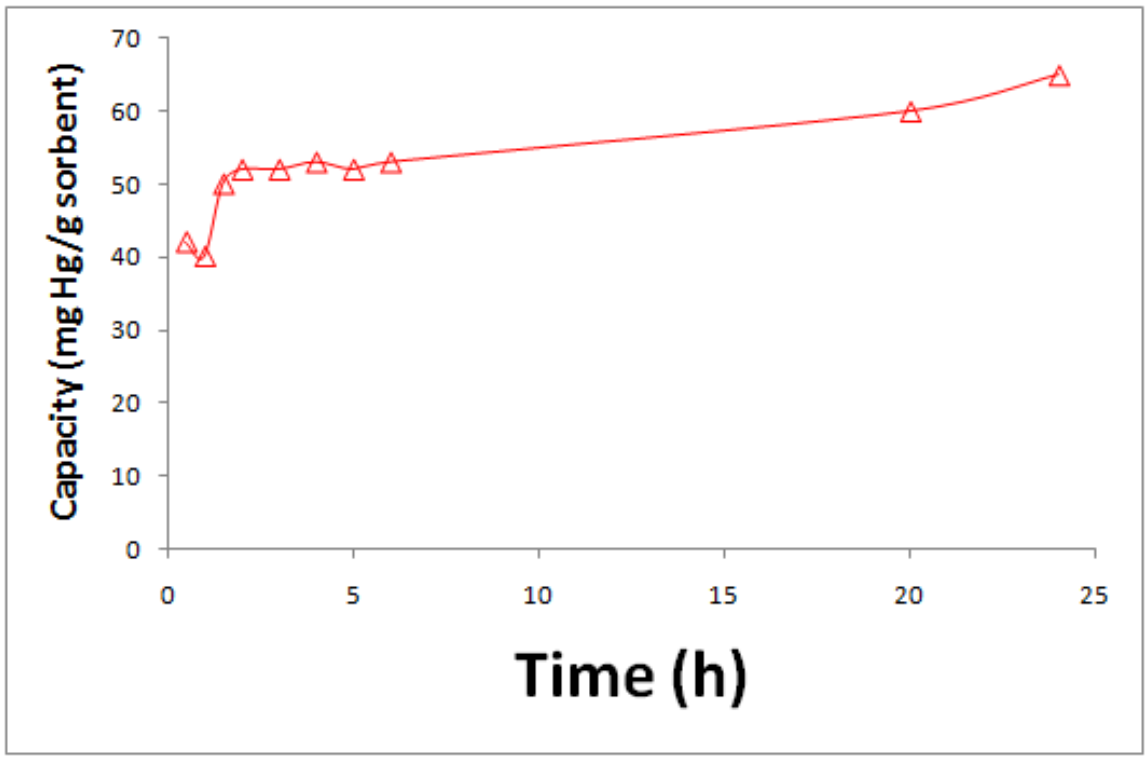
BATCH TEST



Experimental Conditions:
- Initial Hg concentration ~ 100ppb;
- Solution/sorbent ratio = 2000 mL/g;
- Volume = 500 mL;
- Mercury Detection Method: EPA 1631

- Nanomyte™ Sorbent reduced mercury **<1 ppb** in 45 minutes
- Sorbent reduced mercury to **0.02 ppb** in 6 hours

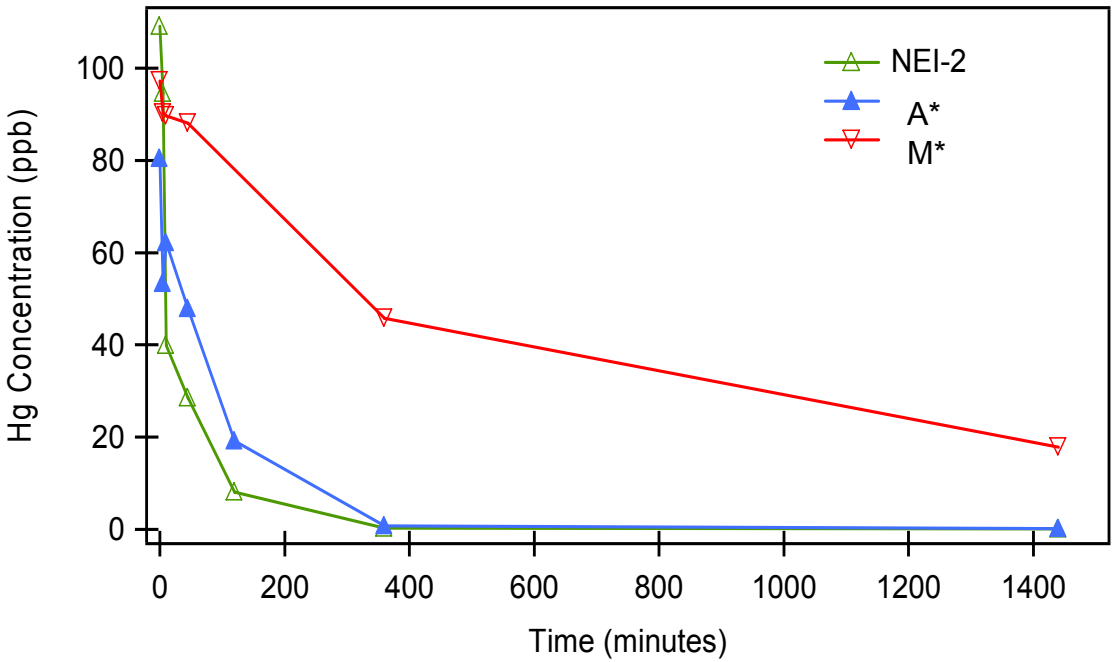
Sorbent Loading (Type I) Capacity



- **Experimental Conditions**:
  - Initial pH = 6.3;
  - Initial Hg conc. = 185 ppm;
  - Volume = 500 mL

Sorbent loading capacity: ~70 ± 12 mg Hg/g of sorbent
50% of the capacity used in < 30 minutes; 80% in < 2 hrs

NEI Sorbent (Type II)

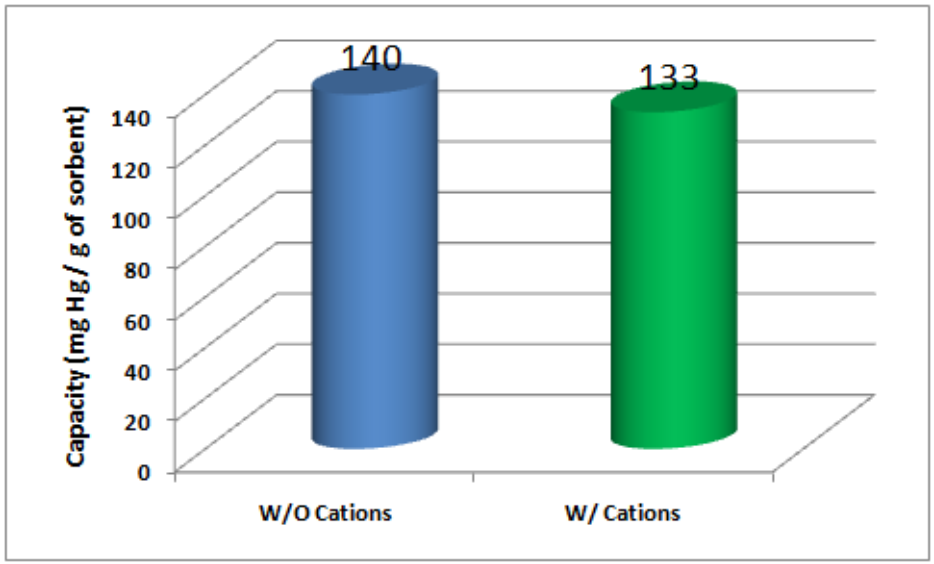


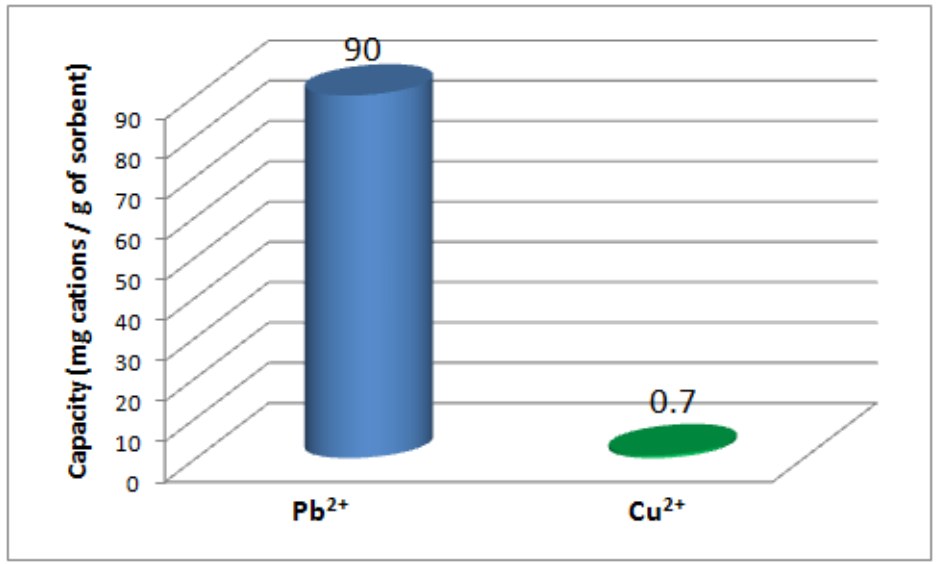
Experimental Conditions:
- Initial Hg concentration ~ 100ppb
- Solution/sorbent ratio = 2000 mL/g
- Volume = 500 mL
- Mercury Detection Method: EPA 1631

- Sorbent reduced mercury concentration to **<0.24 ppb** in 6 hours
- Sorbent reduced mercury to **0.07 ppb** in 24 hours

- **Sorbent loading capacity:** ≥ 140 ± 1 mg Hg/ g of sorbent

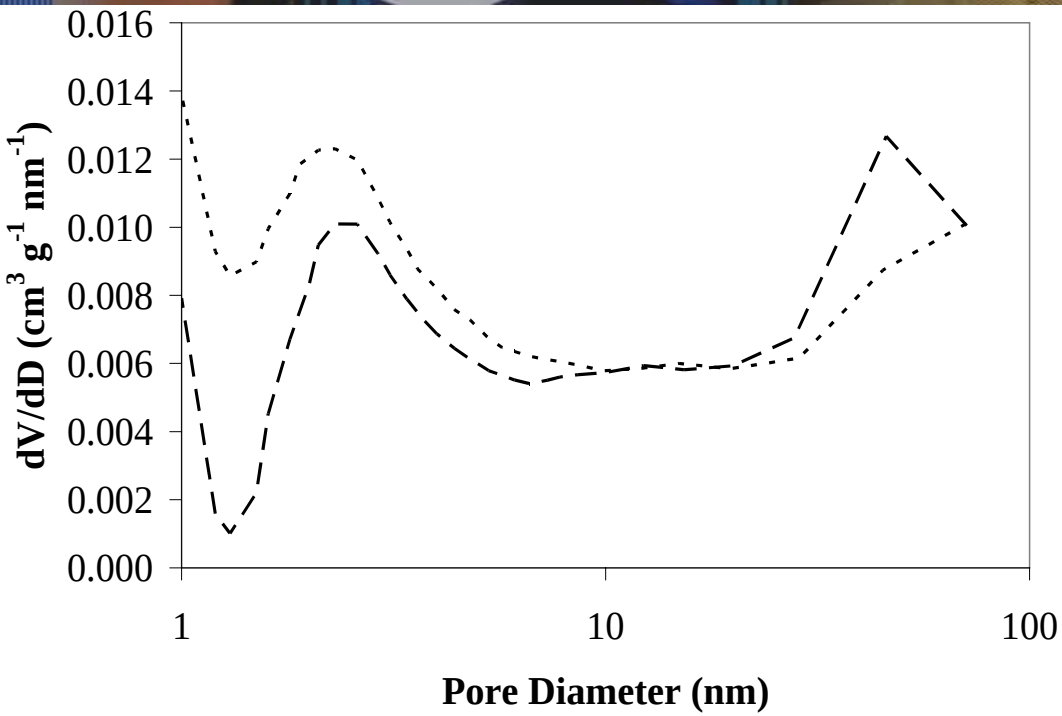
Effect of Competing Cations (Type II Sorbent)





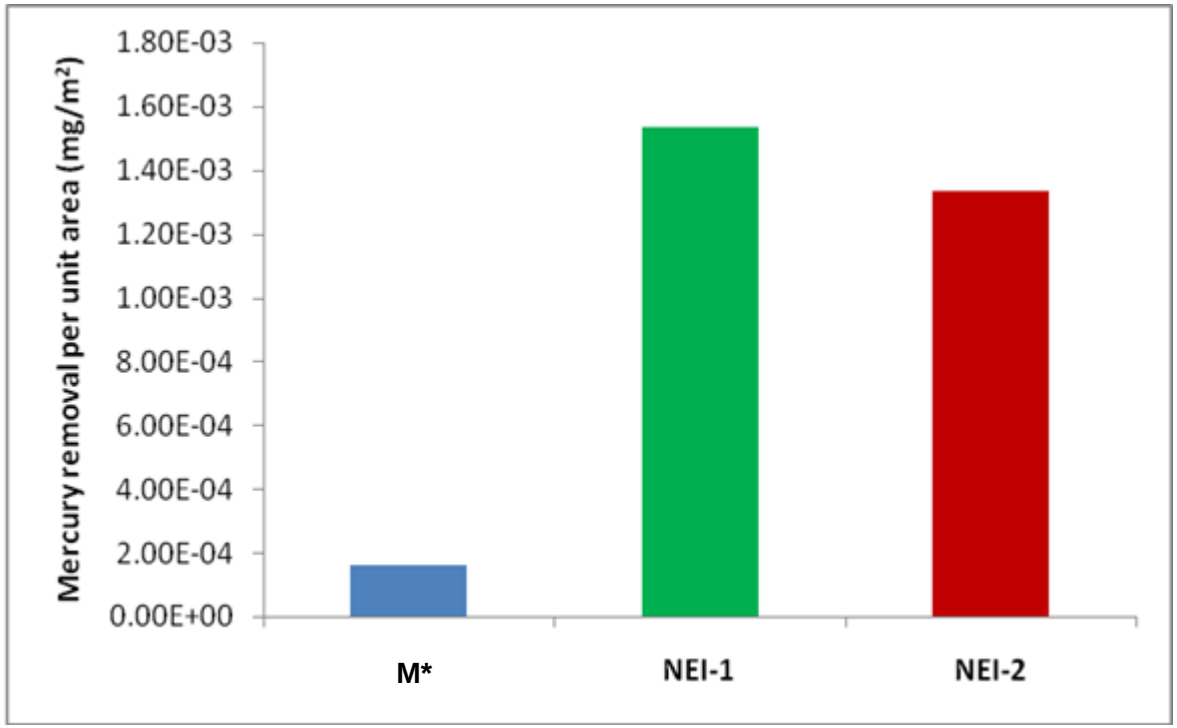
- **Experimental conditions:**
  - Initial concentration: Equimolar amount of Hg^{2+}, Pb^{2+} and Cu^{2+} (12.5 mM)
  - pH 5.6 – 5.7
- Presence of lead and copper do not significantly affect Hg adsorption
- There is greater competition from lead compared to copper

Open Pore Structure – Bimodal Distribution



- The sorbent has a significant pore volume arising from pores of <2 nm (micropores) up to pore of > 50 nm (macropores) - derived from N_2 isotherm
- Open pore structure leads to highly accessible adsorption sites

Highly Accessible Reaction Sites



- Surface Area of M* > 500 m^2/g;
- NEI - Type I = 141 m^2/g; NEI – Type 2 = 136 m^2/g
- NEI's sorbents have significantly higher adsorption per unit area

Summary

- NEI's Nanomyte™ sorbents are available in two Types – high rate (Type I) & high capacity (Type II)
- Type I can reduce mercury levels to < 0.02 ppb (in 24 h)
- Type II can reduce mercury levels to < 0.07 ppb (in 24 h)
- Type I has mercury adsorption capacity of 70±12 mg Hg/g
- Type II has mercury adsorption capacity of 140±1mg Hg/g)
- The sorbents can be aggregated to desired particle morphology

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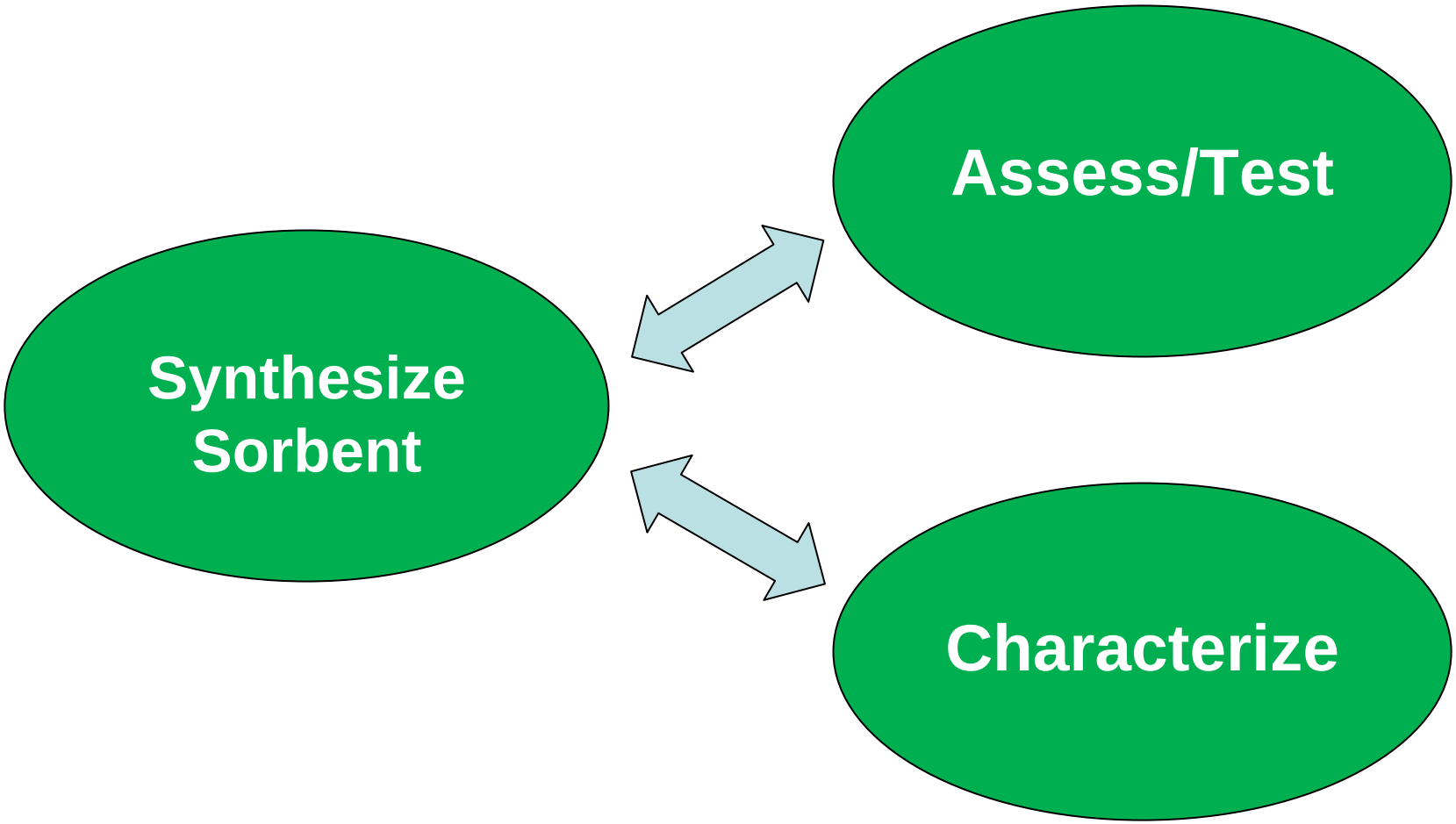
Path Forward



Next Steps

- Determine the performance of the NEI sorbent in different mercury contaminated ground waters (simulated and actual) to evaluate the versatility of the sorbent
- Determine the mechanistic phenomena on the surface of the nanoparticles
- Evaluate the NEI sorbent in a field study at a site where mercury remediation is needed

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