METAL RECOVERY

Recovery of Metal Contaminants from Industrial Wastewaters with Magnetic NanoComposites in a Novel Continuous Flow Process System

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Funding Amount: $495,127

Brief:

Acid rock drainage (ARD) is a serious environmental issue that requires remediation at over 300 identified sites in Montana. To address this imminent need, researchers are leveraging ion exchange synthesis technology under development at UM with a transport reactor system under development at MT Tech. The novel magnetic nanoparticles created at UM will be utilized in the transport reactor system to clean wastewater by extracting and concentrating heavy metal contaminants in a form that is amenable to recovery of marketable high-purity metals such as copper, manganese, and zinc.

Objectives and Progress:

1. Wastewater characterization: fifteen local surface water sites and nine flooded underground mine complexes have been sampled and analyzed for water quality to provide specific chemical targets and mixtures for treatment in the flow reactor.
   - **A.** Copper, manganese, and zinc were selected as the initial target metals for the pilot transport reactor system.
   - **B.** Collection of wastewater samples from Montana sites is underway; these samples will be treated in the continuous flow reactor to confirm the process.
2. Synthesis of iron-magnetic nanoparticles modified for metal ion capture:
   - **A.** Demonstrated that metals are efficiently recovered following adsorption by the magnetic nanoparticles and the nanoparticles are reusable after recovery.
   - **B.** Demonstrated that the magnetic nanoparticles capture metal at rates 50 times faster than previously reported for 300 micron composite particles with similar metal ion capacities.
   - **C.** Scaled up the synthesis process from 1-5 g to 40 g, which is sufficient for use in the pilot pipeline reactor and is a strong indicator that further scale up will not be a problem.
3. Continuous flow reactor design, construction, commissioning, and operation:
   - **A.** The 4th generation continuous flow reactor has been constructed and will be operational in January 2017. A vertical column configuration was adopted to overcome nano-particle agglomeration issues.

continued

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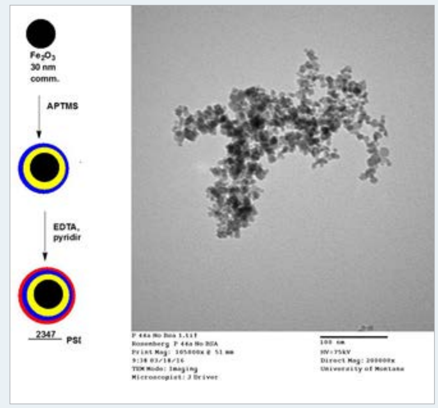
B. Routinely attain particle capture efficiencies in excess of 98% using a single in-line electromagnet.

C. Commissioned an electrowinning cell to evaluate metal reduction from the strip solutions; secured parameters for independently producing copper and zinc cathodes.

4. Secure fundamental aqueous processing data and generate process models:

   A. Developed a wastewater parameter database which will be used to guide experimental design and interpret experimental results.

   B. A student design team is constructing a manganese electrowinning cell.



Return on Investment:

- **Jobs:**
  - 0.33 faculty
  - 1 postdoctoral scholar
  - 2.75 graduate research assistants (Ph.D. or M.S. students)
  - 5 undergraduate research assistants
  - 1 technician
- **Connections—private sector partnerships:**
  - Water and Environmental Technologies, a local environmental engineering firm, expressed interest in the technology for recovering selenium from wastewater.
  - A representative from Barrick Golden Sunlight expressed interest in technology to address a copper contamination issue they are experiencing with an intermediate process stream.
- **Leverage—additional grant funds received:**
  - Submitted on August 2, 2016, the NSF EPSCoR Track-1 RII proposal for the Montana Restoration and Environmental Materials Initiative includes research intended to assess another application of the magnetic nanoparticle/pipeline reactor technology. The total funding request of $20,000,000 includes approximately $100,000 for the reactor study.
  - Water and Environmental Technologies, which has a record of technology development, agreed to partner on a National Science Foundation Small Business Technology Transfer (NSF-STTR) proposal focusing on the recovery of selenium from wastewater generated during coal production and processing. The proposal was submitted in December, 2016 with a requested budget of $224,996.
- **Output:**

  UM's success in establishing the requisite magnetic core and silica coating dimensions and their demonstration of high metal capture rates, stripping, and reuse have provided essential data that is being used to optimize the reactor design and operation.

  MT has constructed a fully operational pilot-scale reactor and performance testing is underway. Results to date have shown that, with just a single in-line electromagnet, the magnetic particle capture is extremely efficient, thus eliminating the most serious concern relative to reactor design and scale-up.

  For eventual industrial acceptance and commercial development, it is mandatory to demonstrate that the particle synthesis process and the reactor can be scaled up. Highly favorable results obtained with both the scale-up of the magnetic nanoparticle synthesis process at UM and the particle capture efficiency in the pilot-scale transport reactor at MTech provide a strong indication that further scale-up should not be a problem.