Research Brief 186: DEMET – Converting Waste into a Resource

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Superfund Research Program

http://www.niehs.nih.gov/srp/

Background

While most modern mining and industrial operations are required to meet stringent environmental regulations, there is little or no oversight of many abandoned mines. Mine runoff and acid rock drainage (ARD) are common occurrences and arise at roughly 10% of abandoned U.S. mines. Water flowing from abandoned mines can contain 10-1000+ parts per million (ppm) of metals. These metals are persistant and often toxic pollutants and have contaminated more than 12,000 miles of U.S. rivers and streams. Even low levels of metal contamination (10-30 parts per billion [ppb]) can kill fish and aquatic insects, stunt plant growth, and disrupt stream ecosystems for several miles.

ARD continues at some mines that have not been used for more than a century, yet there is little economic incentive to correct this problem.

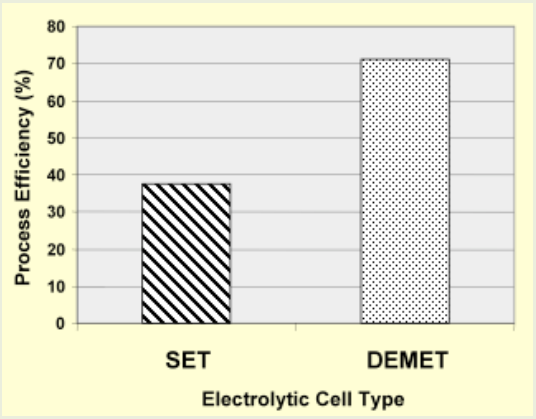
With Phase 1 and Phase 2 Small Business Innovation Research (SBIR) funds from the SRP, Dr. Patrick James at Tesla Laboratories, Inc. is leading efforts to develop and test Dynamic Electrolytic Mine Effluent Treatment (DEMET) – a novel, versatile, and improved electrowinning technology. DEMET works with a variety of metals, singly or in mixtures, and can be used to treat a wide range of contaminant sources. The technology provides practical removal and reclamation of low concentrations of metals in water, and the metal reclamation achieved provides an economic incentive to treat sources currently allowed to contaminate the environment.

Advances

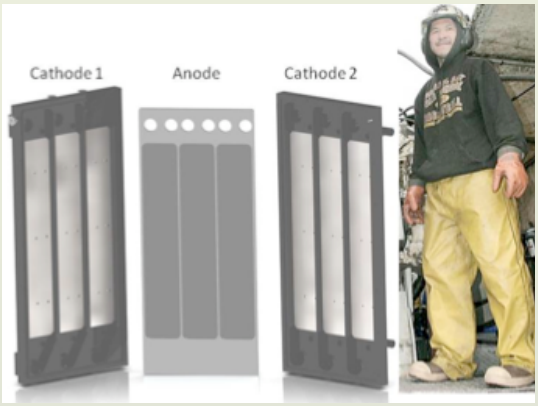
Commonly used technologies (e.g., cementation and conventional electrowinning) are not practical for removing metals from dilute and low volume wastewater flows. Conventional spouted electrode technology (SET) systems, where the cathode is a moving packed bed of conductive particles work better but are still limited in the regime of interest by fatal flaws. In these cells, electrical conduction paths are continuously maintained between the cathode current collector assembly and the moving bed of cathode particles. The solution containing the metal contaminants (electrolytes) is jetted upwards. The fluid velocity drops at the top of the bed, and the suspended particles fall onto the packed bed top and the metal ions are reduced (plated) onto the packed bed portion of the particulate cathode. Use of an electrolyte jet to churn the bed dominates the overall power requirements and limits their applicability at the low metal concentrations of interest.

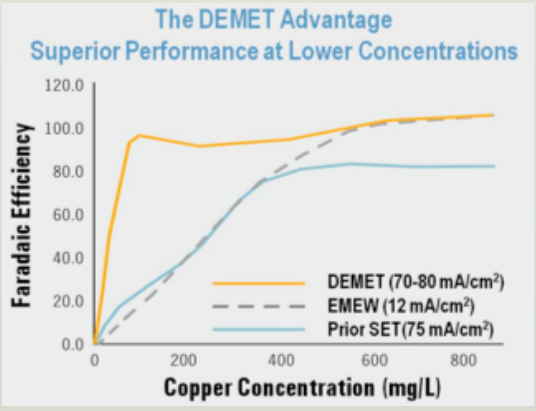
The Tesla research team introduced two significant technical innovations to such moving bed systems to create *patent-pending* DEMET:

- Mechanical, not jetted electrolyte driven, churning of the cathode bed was developed. This greatly reduces overall power consumption (~doubles efficiency) and enhances cell durability. Mechanical churning further allows for unprecedented process optimization via the precise and independent control of the bed churn rate and electrolyte flow rate to adjust the process for specific contaminant concentrations.



Process efficiency comparison





10 GPM Prototype DEMET Cell

- Three chamber cell design. This reduces system costs by more fully utilizing costly anodes and improves proton collection from the anode. The result is improved technology practicality and more widespread utility.

Dr. James' group has demonstrated that DEMET can remove copper, nickel, and metals mixtures from dilute sources simulating ARD waste streams. Lab tests comparing DEMET to conventional spouted electrode technology (SET) approaches show that DEMET dramatically increases recovery of copper with yields of 71% using DEMET and 38% with the conventional system. DEMET also extends the lower limit of utility by an order of magnitude (from ~500 ppm to ~30 ppm) over competitive spouted electrode approaches. That is, DEMET extends practical metals electrowinning down to previously inaccessible regimes typical of ARD streams.

Tesla is currently preparing to conduct prototype validation testing at the Summitville Mine Superfund Site in Colorado which annually discharges nearly half a million pounds of copper in its ARD. Their estimates, which include 50% of profit from sale of the DEMET recovered copper going back to Tesla, indicate that the process could generate $50,000 to $225,000 in revenue for the taxpayers at anticipated long term average copper prices ranging from $2.0/lb to $2.4/lb.

The team is also developing the next generation (GEN2) of DEMET. While retaining the benefits of the core DEMET technology, the GEN2 version provides unprecedented new added functionality. The GEN2 improvements open numerous new doors presently not accessible to conventional electrowinning technologies. Of note, the GEN2 incarnation will generate a concentrated stream of the target metal from the dilute target stream. This concentrated product stream is then amenable to treatment and metal recovery by GEN1 DEMET and existing conventional technologies. In this manner, DEMET can work with and augment the performance of existing treatment/recovery systems. The new system should also be able to separate iron from the ARD streams to produce the value-added product ferrous sulfate ($FeSO_4$) and they are looking for opportunities to demonstrate this. $FeSO_4$ has many industrial uses and is ~10 times more valuable than iron metal and thus provides an opportunity for profitable DEMET removal of iron from contaminated streams. This is significant as iron is present at high levels at many mining and ARD sites.

Significance

The Tesla scientists have demonstrated that DEMET works with various common contaminants and contaminant mixtures. The compact technology is reagentless, needs no feedstream pretreatment, reduces sludge, and recovers contaminants as compact, pure, and saleable products.

DEMET won 3rd place honors in the Innovation Competition at Midwest Clean Tech in 2009.

Tesla Laboratories and Dr. James have formed a spin-off company (Blue Planet Strategies, LLC) to commercialize the DEMET technology. They have been making excellent progress and currently are working with strategic development partners in the copper mining and water treatment industries to scale-up and rapidly move the DEMET technology to into the market. They have been invited to present the business opportunity to potential investors at the 2010 New York Venture Summit (June 17th) and are currently in early-stage discussions with several Angel investor groups. They continue to actively seek stakeholders and end-users for additional strategic alliances and market intelligence and additional funding for facilitating the entry of DEMET into the market as a shovel-ready treatment option during 2011.

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