High-Efficiency Toxic Trace Metal Removal From Industrial Wastewater

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Environmental Problem

Mercury is a harmful neurotoxin that is readily absorbed by the body from the surrounding environment, through the consumption of fish caught in mercury-contaminated waters as well as through inhalation of vapors from spills, incinerators, and industries that burn mercury-containing fuels. Exposure to mercury can permanently damage the brain, kidneys, and developing fetuses, and young children are particularly at risk. Heightened concern regarding the accumulation of mercury in the aquatic environment led EPA to lower the limit of mercury discharge levels for industries, and several states are considering requirements that mercury discharge levels be no greater than those in the ambient receiving waters. An effective treatment technology that will remove mercury and other toxic trace metals from industrial wastewater before it enters natural water systems is needed.

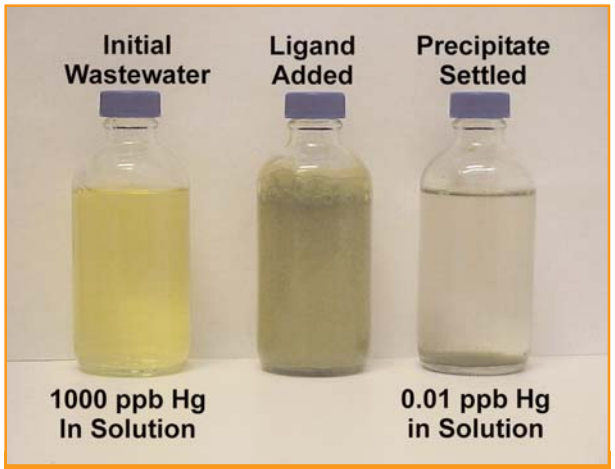
SBIR Technology Solution

With support from EPA's SBIR Program, Frontier GeoSciences, Inc., pursued the implementation of a toxic metal chelating agent, FGS-MCX. FGS-MCX exhaustively complexes most dissolved toxic trace metals of concern, including silver (Ag), cadmium (Cd), copper (Cu), mercury (Hg), lead (Pb), selenium (Se(IV)), arsenic (As(III)), zinc (Zn), and thallium (Tl). In most cases, FGS-MCX has the ability to strip toxic trace metals from indigenous, competitive ligands, such as ethylenediamine tetraacetic acid (EDTA). The FGS-MCX/metal complex is insoluble in the aqueous phase and, thus, precipitates efficiently in solution. FGS-MCX complexes Hg greater than 99.9% from pH 1-12, and 99.999% from pH 3-6.

Toxicity studies of the binding reagent indicated that FGS-MCX is environmentally nontoxic. FGS-MCX preferably binds to lower valence state target metals such as As(III) and Se(IV). The FGS-MCX reagent has a binding hierarchy with typical target metals, in order of most preferred metals to least preferred: Hg > Ag > Cu, Ni > Cd, Pb > Co, Se(IV) > Fe > As > Zn > V > Tl > Cr. The particle formation of the FGS-MCX-metal complex was studied to ascertain the best separation strategy for high-flow process implementation. Reagent concentration at a fixed metal/FGS-MCX ratio had only a small effect on the aggregation kinetics, but increasing the FGS-MCX concentration sped up the aggregation process. Adding a salt also accelerates aggregation. In all cases, improved aggregation means better separation characteristics.

Commercialization Information

A batch pilot plant was constructed and still is under study for its applicability to low-volume laboratory environments. The pilot plant has processed more than 500 gallons of high-concentration toxic trace metal waste. The effluent was at least an order of magnitude below the local authority's discharge requirements. More than a dozen client sites have been characterized and tested for the applicability of FGS-MCX treatment. For example, natural gas-produced water and laboratory digestion waste were treated by a simple 50 ppm FGS-MCX addition. In the produced water case, the Hg was reduced from 9,569 μg/L to 0.035 μg/L, 285-fold lower than the ocean discharge limit. The laboratory digest wastewater saw the Hg concentrations drop from 6,214 μg/L to 16 μg/L, 12.5-fold lower than the municipal waste limit. The natural gas platform now uses MCX binding as the primary treatment method for a



The FGS-MCX metal complex is insoluble in the aqueous phase, and thus precipitates efficiently in solution. The flocculation process is shown in the photograph above.

million-gallons-per-day wastewater treatment system. Frontier GeoSciences also recently received a 64-ton order for FGS-MCX from Malaysia.

Additionally, the SBIR project directly resulted in a novel pilot online continuous analyzer being placed on a natural gas platform. FGS-MCX was demonstrated to work as a potential additive to wet scrubbers in the coal-fired power plant industry. EPA awarded additional funds to Frontier GeoSciences to pursue the feasibility of this application. Additional funds also have been obtained from an industrial partner that is a large natural gas producer.

Company History

Located in Seattle, Washington, Frontier GeoSciences, Inc., is an industry leader in trace metals analysis. With a state-of-the-art analytical laboratory and research facility, the company specializes in ultra-low detection of trace metals in multiple matrices. Frontier GeoSciences' mission is to provide the very best data to support clients' critical environmental and economic decisions. The company provides chemical solutions for the effective control of toxic metals to the environment. Frontier GeoSciences' scientists are widely published, and are worldwide experts in areas as diverse as mercury speciation and arsenic monitoring and remediation.

SBIR Impact

- The effluents of many industrial processes as well as surface and ground waters from historically polluted sites often contain unacceptably high levels of mercury and other toxic metals.
- Frontier GeoSciences implemented a toxic metal chelating agent, FGS-MCX, that strips metals from the natural ligand/metal complex.
- FGS-MCX binding is the primary treatment method for a million-gallons-per-day wastewater treatment system for a natural gas platform.
- FGS-MCX was demonstrated to work as potential additive to wet scrubbers in the coal-fired power plant industry.