Optimizing ZVI Formulations for the Degradation of Chlorinated Hydrocarbons: Effects of Composition and Particle Size

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Background/Objectives. Zero valent iron (ZVI) is a powerful reductant used to decontaminate soil and groundwater containing halogenated hydrocarbons and other toxic contaminants. ZVI products have disparate properties and remediation performance is highly dependent on material characteristics including include particle size, composition, and surface modifications. Understanding and optimizing the relationship between ZVI properties and remediation performance can result in more rapid and complete in situ remediation.

Approach/Activities. The research program investigated the ability of several types of ZVI to degrade aqueous phase perchloroethylene, trichloroethylene, and chloroform. Dry powders that were studied included sub-micrometer powder (NZVI), carbonyl iron, and screened commodity iron ranging in size from 600 mesh (20 mm) to 50 mesh (300 mm). Colloidal products that were studied included OnMaterials Z-Loy™ MicroMetal, a ZVI product suspended in glycerol and Z-Loy™ AquaMetal, a ZVI product suspended in water. Z-Loy™ PRB, an aqueous suspension of microscale iron was also evaluated. Surface modified products include small additions of palladium and iron sulfide that were deposited onto the surface of Z-Loy™ AquaMetal ZVI and Z-Loy™ PRB products. Reactivity was evaluated by adding 2 g/L of colloidal products and 10 to 50 g L of commodity microscale products to closed bottles. Composition was measured using headspace gas and a gas chromatograph with an ECD detector. Experiments were also performed to evaluate the rates of hydrogen gas generated by the reaction of ZVI and water.

Results/Lessons Learned. Pseudo first order kinetics were measured with correlation coefficients generally greater than 0.99. The study indicated that for chlorinated ethenes, particle size had a modest effect of reactions kinetics. Surface modification had a much more dramatic effect, particularly for the reaction of sulfidized colloidal products with chlorinated ethenes. These products exhibited pseudo-first order rate constants 30 to 50 times greater than dry commodity products. For chlorinated methanes, surface modifications had a smaller effect on degradation rates. Sulfidized products also decreased the rates of hydrogen gas generation potentially increasing reactivity capacity and lifetime.