

## A Combined Approach Using Colloidal Zero Valent Iron and Colloidal Activated Carbon

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**Background/Objectives.** This paper explores combining the sorptive properties of colloidal activated carbon (cAC) with the reductive properties of colloidal zero valent iron (cZVI) to remediate contaminated soil and groundwater and to provide control over contaminant flux of both parent and daughter products in solution. cZVI provides a highly reducing groundwater environment, and cZVI can remediate chlorinated ethenes by both hydrogenolysis and beta elimination pathways. While the beta elimination pathway degrades PCE to ethene and ethane via an acetylene intermediate, thereby avoiding the formation of cis-DCE and VC, some generation of daughter products through the hydrogenolysis pathway is unavoidable. cAC removes contaminants from aqueous solution by sorption and provides a matrix for the degradation of contaminants. The sorptive properties of cAC increase the residence time of the chlorinated solvents to allow degradation to environmentally benign end products.

The colloidal nature of the activated carbon and ZVI allows the materials to be co-applied at low pressure with uniform distribution in the subsurface to ensure contact with contaminants. This dual technology approach allows the rapid removal of contaminants and provides long term treatment with a single application of product.

**Approach/Activities.** The sorption and degradation of PCE by activated carbon and ZVI was analyzed in batch and column laboratory studies. Batch studies were performed analyzing cAC and cZVI in the presence of a chlorinated solvent degrading bacteria inoculum. To monitor both the sorption of PCE onto activated carbon as well as any degradation, the PCE and daughter product concentrations in the aqueous solution were monitored, and organic extractions were also performed to measure the total mass balance across all phases (water, soil, colloidal materials). Column studies were completed to study the transport properties of these colloidal agents by measuring breakthrough curves.

**Results/ Lessons Learned.** The data from these studies revealed that using cAC and cZVI together allows rapid removal of contaminants from solution as well as the degradation of contaminant over time. Treated samples show approximately 50 % less cis-DCE and VC at peak concentration than controls containing dechlorinating bacteria alone. Contaminants are sorbed rapidly to cAC, yet the contaminants remain available to be degraded either by contaminant degrading bacteria or by cZVI. The sorptive capacity of cAC is not diminished by the presence of cZVI; rather the degradation of contaminants either by bacteria or by cZVI allows regeneration of cAC and long-term control over matrix back diffusion. Transport studies show that both colloidal formulations are readily transported through conductive zones.