

DEGRADATION OF PFAS USING METAL-CATALYZED CHEMICAL OXIDATION AT NEAR AMBIENT CONDITIONS

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Background/Objectives:

The widespread use of per- and polyfluoroalkyl substances (PFAS) has led to their pervasive presence in various environmental matrices, including water, soils, sediments, biological organisms, consumer products, industrial systems, and atmospheric emissions. The persistence and mobility of PFAS, coupled with their resistance to conventional degradation processes, have made them a significant environmental and public health concern. Addressing PFAS contamination requires innovative approaches that go beyond traditional methods, as their chemical stability and widespread distribution pose challenges for effective remediation. One promising solution is "Hot ISCO" (in situ chemical oxidation), a metal-catalyzed chemical oxidation technique capable of degrading PFAS. Hot ISCO utilizes near-ambient temperatures ($\leq 40^{\circ}\text{C}$) and metal-activated catalytic reactions to break the strong carbon-fluorine bonds that make PFAS so resistant to degradation. This approach has demonstrated potential for reducing PFAS concentrations in contaminated matrices such as soils and groundwater, offering a viable pathway for their destruction. By targeting PFAS at their source, Hot ISCO represents a critical advancement in remediation strategies, providing an opportunity to mitigate the environmental and health risks associated with these persistent compounds.

Approach/Activities:

Parsons has developed a novel approach to PFAS remediation through a Canadian-patented methodology known as hot in situ chemical oxidation (Hot ISCO). Classic approaches to oxidation require prohibitive inputs of heat to initiate and propagate the oxidation reactions. To avoid this, Parsons has developed a blend of metal-based catalysts capable of activating applied oxidants under a low temperature ($\leq 40^{\circ}\text{C}$) environment. This enables a slow, steady release of a broad range of oxidizing radicals which efficiently degrade PFAS, including PFOS, PFOA, 6:2 FTS, PFBA, TFA, and GenX.

Initial laboratory work has identified the roles of temperature, pH, metal type/concentration, oxidant type/concentration, oxidant dosing profile, and the impact of dissolved organic matter. Additional experiments have identified the effectiveness of Hot ISCO on a variety of matrices, including aqueous, solids, and filtration media. Subsequent field trials have demonstrated >90% removal of PFAS in water. Fluoride mass balance closure was dependent on the PFAS investigated, with free fluoride recovery for PFAS post-destruction ranging from ~30% (PFOA) to ~90% (TFA). The biggest challenge to achieving complete fluoride mass balance is due to the high acidity and ionic strength of the system that occurs with increasing number and/or concentration of oxidant doses.

Field demonstration of Hot ISCO have identified significant degradation of PFAS when applied ex-situ to PFAS-impacted groundwater (~300 liters). As identified in the benchtop studies, there were challenges in identifying fluoride mass balance due to the increasingly complex post-remediation matrix.

Results/Lessons Learned:

This presentation will share the lessons learned from five years of research and development, highlighting the potential of Hot ISCO as a cost-effective solution for PFAS destruction in diverse environmental conditions. The most significant lessons learned are related to the effectiveness of PFAS degradation, which has been found to depend on several factors including:

- PFAS type/concentration
- Oxidant concentration per dose
- Oxidant doses per investigation
- Metal type and concentration
- Matrix components, including inorganic (e.g. chloride) and organic (e.g. dissolved organic matter)

Overall, this presentation identifies Hot ISCO as a viable option for the degradation of PFAS in complex matrices under near-ambient temperatures and pressures.

About The Author

David Patch, PhD, is an analytical chemist with academic and industrial experience specializing in the analysis and remediation of legacy and emerging environmental contaminants, including metals, nanomaterials, microplastics, and PFAS. He develops novel analytical methods for complex environmental and product matrices.

