Reductive Technologies for Remediation of Groundwater

PeroxyChem offers a variety of reductive technologies for *in situ* remediation of groundwater. Our *in situ* chemical reduction (ISCR) and enhanced reductive declorination (ERD) products are applicable for treatment of a wide range of halogenated contaminants such as chlorinated solvents, chlorobenzenes, energetics, and some pesticides, herbicides, and haloalkanes. The following provides an overview of the different properties, mechanisms, and key attributes of our various reductive product offerings for groundwater applications.

OVERVIEW OF PRODUCTS

EHC® ISCR Reagent combines microscale zero-valent iron (ZVI) and organic carbon promoting both abiotic and biotic treatment mechanisms. It is the longest lasting of our product offerings and also offers the highest reducing power. EHC is the culmination of years of research in finding the optimal balance of reactivity and longevity.

EHC® Liquid Reagent is a combination of ELS™ Microemulsion and ferrous iron to provide both abiotic and biotic reduction of contaminants in an easy-to-use liquid form.

ELS™ Microemulsion is a 25% concentration lecithin microemulsion; a long-lasting, food-grade, liquid organic carbon substrate for enhanced reductive dechlorination / anaerobic bioremediation. ELS is also available as 100% ELS Concentrate that can be emusfied in the field.

Product	Composition	Mechanisms		
		Enhanced Reductive Dechlorination	Chemical Reduction	
			Direct	Indirect
EHC	• 60% Organic Carbon (plant particles) • 40% Micro-Scale ZVI	Yes	Yes	Yes
EHC Liquid	• Emulsified Lecithin Substrate • Soluble Organo-Iron Powder (Fe(II))	Yes	No	Yes
ELS	• Emulsified Lecithin Substrate • Availalble as 25% Microemulsion and 100% Concentrate	Yes	No	No

OVERVIEW OF MECHANISMS

Enhanced Reductive Dechlorination: The addition of organic carbon to the subsurface will support the growth of indigenous heterotrophic bacteria in the groundwater environment. As the bacteria feed on the organic carbon, the bacteria consume dissolved oxygen and other electron acceptors, thereby reducing the redox potential in groundwater. As the carbon substrate is being fermented, a variety of volatile fatty acids (VFAs) such as lactic, propionic and butyric acids are released into the groundwater plume and serve as electron donors for other bacteria, including dehalogenators. EHC, EHC Liquid, and ELS promote enhanced reductive dechlorination as a treatment mechanism.

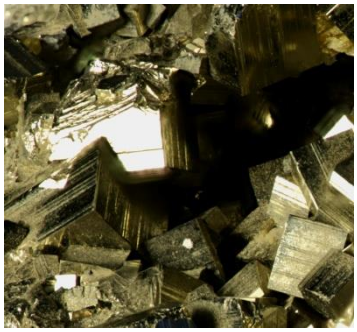
Environmental Solutions

In Situ Reductive Remediation

Technology Overview

Direct Chemical Reduction refers to the redox reaction that occurs in direct contact with ZVI in which the halogenated compound gains electrons and the iron donates electrons. This reaction occurs at the iron particle interface and is limited to the product placement zone. EHC promotes direct chemical reduction as a treatment mechanism.

Indirect Chemical Reduction refers to abiotic degradation in contact with ferrous iron corrosion products. Ferrous iron can either be added directly with EHC Liquid or it can be slowly released into groundwater as the result of ZVI corrosion. In either scenario, dissolved ferrous iron may precipitate out as reduced iron minerals, including iron sulfides (e.g. pyrite, mackinawite, greigite) and oxides (e.g. magnetite), which will support abiotic dechlorination reactions. As ferrous iron may be transported with groundwater, the zone with indirect chemical reduction may extend beyond the substrate placement zone. EHC and EHC Liquid promote indirect chemical reduction as a treatment mechanism.

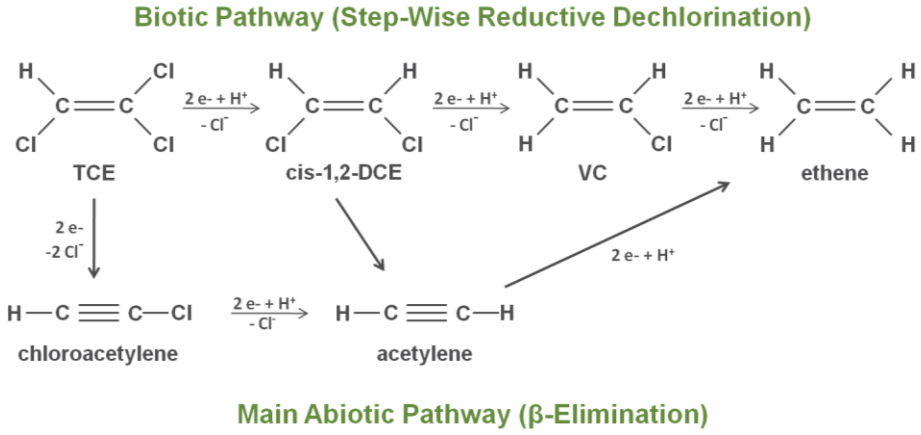


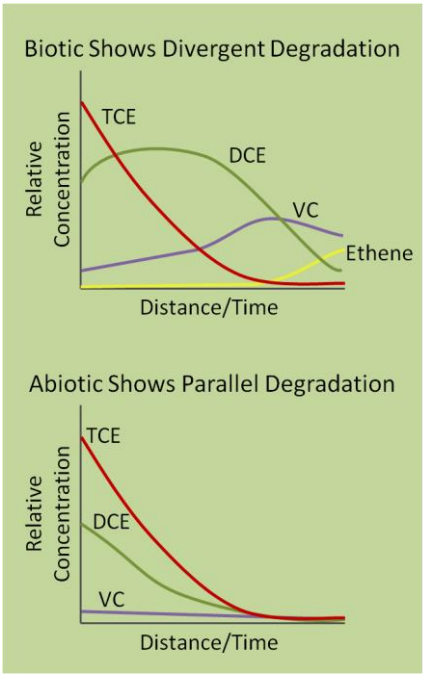
Pyrite (FeS_2)

Magnetite (Fe_3O_4)

REACTION PATHWAYS

The addition of organic carbon will promote conventional step-wise reductive dechlorination reactions, whereas the dominant β-elimination abiotic pathway is observed in direct and indirect reduction reactions; limiting the generation of daughter products (very little vinyl chloride has been observed with PeroxyChem's ISCR products).





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PRODUCT ATTRIBUTES AND APPLICATIONS

	EHC® ISCR Reagent	EHC® Liquid Reagent	ELS™ Microemulsion
Physical form as delivered	• Dry powder	• 25% ELS Microemulsion or 100% ELS Concentrate • Soluble organo-iron powder mix (added to emulsion in the field)	• 25% ELS Microemulsion or 100% ELS Concentrate
Key benefits	• Promotes both abiotic and biotic degradation pathways • 3-8+ years longevity* • Natural organic carbon source includes essential nutrients • Combined abiotic and biotic oxygen scavenging quickly establishes reducing conditions • Self-buffered – alkalinity generated from iron corrosion counteracts acid generation from organic carbon fermentation • Years of established, successful use and case studies • Applicable towards a wide range of concentrations and applications • Minimal generation of degradation products	• Promotes both abiotic and biotic pathways • 1-3 years longevity* • Includes nutrients (phosphorous and nitrogen) • Licensed patented technology, exclusive to PeroxyChem • Easy to handle and can be diluted with cold water • Forms stable emulsions • More limited generation of degradation products	• Efficient hydrogen donor for reductive dechlorination – high H release • 1-3 years longevity* • Lecithin's phospholipid structure creates a more stable emulsion compared to hydrophobic substrates, such as oils • Lecithin molecule inherently contains phosphorous and nitrogen that are nutrients for microorganisms • Easy to handle and can be diluted with cold water
Ideal uses	• Plume, source area and barrier applications • Contaminant levels <100 ppm • Residual NAPL (not pooled)	• Plume treatment • Contaminant levels <10 ppm	• Plume treatment • Contaminant levels < 10 ppm
Application methods	• Direct push injection • Hydraulic & pneumatic fracturing • Permeable reactive barriers • Direct application in excavation • Soil mixing	• Direct push injection • Low pressure injection • Gravity feed through existing wells • Recirculation systems	• Direct push injection • Low pressure injection • Gravity feed through existing wells • Recirculation systems

*Depends on application rate and site conditions

For more detailed information, please see the PeroxyChem Contaminants Treated Guide.