Combining *In-Situ* Chemical Reduction and Antimethanogenic Reagents to Achieve Substantial CVOC Reductions

Group 1

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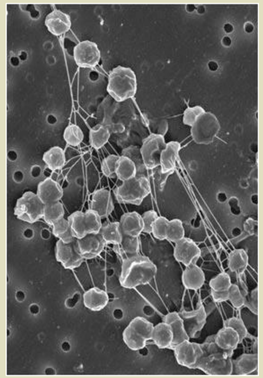
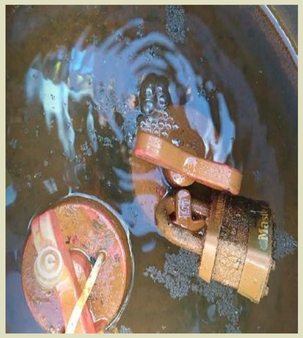
INTRODUCTION

The microbial consumption of organic carbon and common electron donors (*e.g.,* sugars, emulsified vegetable oils, lecithin, various hydrogen release compounds, etc.) used in the remediation of chlorinated solvent sites will result in the fermentation of various by-products and end-products, including the potential for excess methane production. Methanogens/Archea often become the dominant microbial species in these reducing environments and are the only known microorganisms capable of producing methane. Additionally, within these environments, methanogens have the ability to double every one to two hours, potentially proliferating much faster than other microbial species, such as *Dehalococcoides.* This population bloom can create large quantities of methane gas, yielding at least three potential consequences related to this response:

- Efficiency/Cost - methane is a waste product in the consumption of the selected remedial reagent, as it represents hydrogen that is not directly benefitting the dechlorination reactions.
- Safety - elevated methane concentrations can exceed current and pending regulations of <1 to <28 ppm in groundwater, and/or <0.5% v/v methane in soil gas. Methane gas can induce vapor migration issues, potentially causing indoor air issues of chlorinated VOCs and exceed LELs.
- Performance – rapid growth of methanogens consumes alkalinity while generating acids increasing the potential for aquifer acidification.





To avoid these issues during the remediation process, proprietary, antimethanogenic reagents, Provect-CH4®, are included in Provectus' solid and liquid remedial technologies for more effective and cost-efficient remediation. Provect-CH4 is a food-grade, natural source of Monacolin K (otherwise known as Lovastatin®) and other statin compounds and/or essential plant oils with a demonstrated ability to prevent excessive methane. Provect-CH4 prevents excessive methane by inhibiting the growth and proliferation of methanogenic archaea by interfering with the biosynthesis of pseudomurein. Also, the antimethanogenic reagents will not inhibit the growth of the dechlorinating bacteria, *Dehalococcoides*.

ANTIMETHANOGENIC SOLID ISCR PROVECT-IR ®

Provect-IR: Provect-IR is a customizable, solid, long-term *in situ* chemical reducing (ISCR) remedial amendment that is a combination of both biotic and abiotic technologies. The primary benefits this technology offers are:

- Multiple, complex, hydrophilic time-released organic carbon sources
- 15%-85% fine-grained, premium ZVI based on site-specific blend
- Chemical oxygen scavengers to help maintain the ZVI

ANTIMETHANOGENIC LIQUID PROVECT-ERD -CH4™

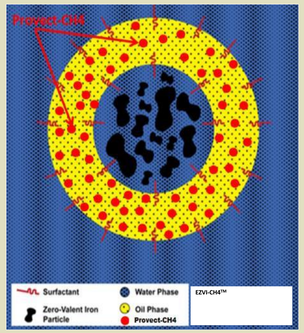
Provect-ERD-CH4: Provect-ERD-CH4 is a site-specific blend of proprietary fermentable carbon sources and optional water-soluble dual-valent iron designed to enhance biological activity. The primary benefits this technology offers are:

- Contains a combination of fast, mid, and long-term H donors
- Dipotassium phosphate for nutrients and pH buffering
- Liquid/Oil anitmethanogenic reagents available for more efficient remediation

ANTIMETHANOGENIC EZVI-CH4™

EZVI-CH4: EZVI-CH4 offers the most advanced, cost-efficient formulation of the NASA patented technology to remediate highly contaminated source areas with biotic and abiotic technologies. The primary benefits this technology offers are:

- Abiotic reactions occur in the aqueous interior of emulsion with highly reactive, premium ZVI. Biotic reactions occur on the exterior of the emulsion.
- Highly reactive ZVI is encapsulated and reacting with hydrophobic CVOCs
- Sequestration of hydrophobic contaminants into vegetable oil membrane



RESULTS

Site A – New Jersey: Field, geochemical and VOC data for two target monitoring wells are presented in the tables below following a Provect-IR soil blending application. Within one month post application, both monitoring wells are starting to show signs of ISCR conditions persisting, indicated by reducing ORP levels and small increases in both ethene and ethane. Additionally, no significant increases in methane were observed since our proprietary antimethanogenic reagents were included with this site-specific blend. Lastly, within only a few months, all VOCs have been reduced by more than 90%.

MW-2						
	Baseline	1 Month	2 Months	4 Months	5 Months	% Reductions
1,1-DCE	1.9	0.34	0	0	0.2	89.5%
cis-1,2-DCE	1800	230	340	300	100	94.4%
PCE	920	22	550	82	6.1	99.3%
TCE	450	28	200	82	11	97.6%
VC	360	220	160	58	36	90.0%
Ethane	2.36	6.8	9.45	95.2	NA	
Ethene	47.3	129	152	45	NA	
Methane	515	863	2,770	3,530	NA	
ORP	NA	-160	-66	-202	NA	
pH	8.31	7.5	7.63	7.58	NA	
DTW	2.89	2.45	2.8	2.01	NA	

MW-8						
	Baseline	1 Month	2 Months	4 Months	5 Months	% Reductions
1,1-DCE	ND	ND	ND	ND	ND	100%
cis-1,2-DCE	2400	54	1.9	1.4	0.55	100.0%
PCE	ND	ND	ND	ND	ND	-
TCE	ND	ND	ND	ND	ND	-
VC	2500	610	20	32	11	99.6%
Ethane	183	159	220	269	NA	
Ethene	218	104	43.5	17.3	NA	
Methane	6,700	6,550	8,180	11,200	NA	
ORP	NA	-121	-52	-153	NA	
pH	7.2	7.22	7	7	NA	
DTW	3.11	4.28	3.05	3.81	NA	

Site B - Florida: Post-remedial groundwater data from two DNAPL source area wells are presented below. The RAO for this site was to inject EZVI-CH4, remediate DNAPL, and achieve the GCTL of 3 ppb for PCE in groundwater. Multiple applications were proposed, though only one would be completed due to unforeseen construction project. Project RAOs were still achieved.

PCE Levels in Groundwater (ppb)							
	Baseline	1 Month	5 Months	13 Months	34 Months	39 Months	Reductions
DW-1	10,300	9,200	16	0.77	0.38	0.38	99.9%
IW-7	159,000	38,100	39,300	660	12.5	1.9	99.9%

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