

Provect-OX™

Self-Activating ISCO / Enhanced Bioremediation Reagent

TECHNOLOGY DESCRIPTION

Provect-OX is an *in situ* chemical oxidation (ISCO) / enhanced bioremediation reagent that uses ferric iron (Fe III) as a safe and effective means of activating persulfate (Patents Pending). Provect-OX oxidizes a wide variety of organic compounds present in impacted soil, sediment and groundwater, including chlorinated solvents, petroleum hydrocarbons, and pesticides. Rodriguez *et al.*, (2014) recently reported that 2 mM Fe(III) and 6 mM persulfate was very effective in rapidly mineralizing even recalcitrant organic compounds such as the synthetic azo dye Orange G (C₁₆H₁₀N₂Na₂O₇S₂).

This advanced activation catalyst is further unique considering its ability to enhance bioremediation processes. This is accomplished via the subsequent utilization of sulfate and iron as terminal electron acceptors for facultative reductive processes. Degradation intermediates generated during pollutant oxidation may act as electron shuttles, allowing the reduction of Fe(III) to Fe(II) in the redox cycling of iron and continued activation of persulfate. This combined remedy provides supplemental treatment mechanisms thereby allowing for more cost-efficient dosing of the product.



WASTEWATER TREATMENT

Like all Provectus products, Provect-OX was developed by experienced practitioners who understand real-world field applications. For example, persulfate oxidant and its activator can be conveniently packaged in a single, pre-mixed bag for ease of use and safe handling. Moreover, due to its safe and non-extreme activation chemistry, Provect-OX will not generate excessive heat / off-gases, nor will it mobilize heavy metals or lead to the generation of secondary impact issues, such as elevated arsenic, chromium, or pH.

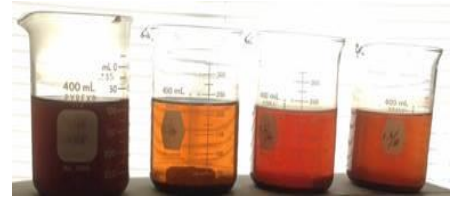
Given these features of safety and effectiveness, Provect-OX can potentially be useful in managing wastewater, industrial process streams, landfill leachate, etc. The economics of the process will be equally important to determine its viability. For example, treating about 50,000 USG/month with 0.2 lbs Provect-OX/USG would require 10,000 lbs at a cost below \$15,000. During treatment, the process would not generate excessive heat and the reactions would be completed in a matter of days.

The material requirements and treatment process/time must be evaluated on a project-specific basis. An example proof-of-concept study is presented below where Provect-Ox was evaluate to pre-treat a wastewater (see inset) containing: Phenol (500 mg/L), 2,4-Dimethylphenol (35 mg/L), Naphthalene (10 mg/L), Benzene (7 mg/L), Toluene (2 mg/L) and Phenanthrene (0.5 mg/L) with 10 mg/L TSS and a pH 8.5 to 9.



Preliminary Jar Tests evaluated the ability of Provect-OX to reduce the organic load and remove color prior to polishing with a secondary carbon (GAC) filter and final discharge to public sewer (under permit). Previous studies showed that 200 lb coconut-shell GAC lasted an estimated 12 hours at ca. 5-gpm (brown color and odor was removed); pre-treatment with permanganate generated large amounts of precipitate.

After 5 days treatment with Provect-Ox at 0, 0.1 lb/USG (3 g/250ml), 0.2 lb/USG (6 g/250ml), and 0.3 lb/USG (9 g/250ml) as shown left from right in the inset. At 0.1 lb/USG the pre-treatment lead to significant discoloration, acceptable reduction in pH, noted decrease in odor, and did not generate as much precipitate when compared to other oxidant treatments. Detailed analysis of organic compound removals were not conducted.



Time		Control	0.1 #/gallon	0.2 #/gallon	0.3 #/gallon
6/24/2014 16:00			3 grams/ 250 mL	6 grams/ 250 mL	9 grams/ 250 mL
			mix	mix	mix
6/24/2014 17:30	pH	8.36	5.21	2.50	2.07
	notes		cloudy rust colored	cloudy rust colored	cloudy rust colored
6/25/2014 8:00	pH	8.19	1.86	1.60	1.48
	notes		< 10% precipitate	< 5% precipitate	<< 5% precipitate

PRIMARY FEATURES:

This technique maximizes the synergy between persulfate and iron for coupled oxidation and enhanced bioremediation: i) sulfate is generated from persulfate, i) Ferric iron (Fe III) is microbiologically reduced to ferrous iron (Fe II) readily supplying electrons to exchange and react with sulfide. Together, sulfide and iron form pyrite, an iron bearing soil mineral with a favorable reductive capacity.

- ◆ **Effective:** Promotes free radical based *in situ* oxidation of a wide-range of organic contaminants. Also provides a unique microbiological component for multiple accelerated attenuation processes.
- ◆ **Efficient:** Significantly lower costs as a result of sub-stoichiometric dosing requirements.
- ◆ **Safe:** Fewer health and safety concerns as compared with use of traditional activation methods such as heat, chelated metals, hydrogen peroxide or pH extremes. Contains built-in activation which eliminates the need for additional and potentially hazardous chemicals required to achieve traditional persulfate activation.
- ◆ **Ease of Use:** Single component product with integrated activator results in simplified logistics and application. No additional containers or multi-step mixing ratios required prior to application. Fewer material compatibility issues.
- ◆ **Improved Performance:** Combined remedy prevents “rebound” which is often seen in other oxidation processes. Maximizes the inherent geochemistry of a “post-oxidation” environment for biologically based attenuation.

LITERATURE CITED:

Rodriguez S, L. Vasquez, D. Costa D, A. Romero and A. Santos. 2014. Oxidation of Orange G by Persulfate activated by Fe(II), Fe(III) and zero valent iron (ZVI). Chemosphere 101:86-92.

Scalzi, M. and A. Karachalios. 2013. Chemical Oxidation and Biological Attenuation Process for the Treatment of Contaminated Media. US PTO 13/891,934. May, 2013.

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