



Terra Systems, Inc. Sodium and Potassium Persulfate For In Situ Chemical Oxidation (ISCO)

Part of Our Comprehensive Soil and Groundwater Remediation Treatment Train
Solutions

Terra Systems, Inc. is pleased to announce that it is now an authorized distributor of sodium and potassium persulfate from United Initiators, Inc. (UI) within the United States environmental remediation market. The combined resources of UI and Terra Systems bring together decades of both biological and chemical experience and expertise to the soil and groundwater remediation marketplace.

Terra Systems Inc. has expanded its product portfolio to include the activation of persulfates as part of our recommended comprehensive soil and groundwater “*Treatment Train Program.*” Our team of innovative scientists and engineers evaluate and make recommendations for many complex sites that could benefit from a combination of ISCO-bio processes such as activated persulfate chemical oxidation for source areas and hot spots, coupled with enhanced bioremediation for the diffuse plume..

We wanted persulfate activation methods that are safer and provide a shorter site recovery time than traditional activation methods, like sodium hydroxide. We have been working with a new activation method using ferrous sulfide (TSI-FSA™) that provides a much safer work environment for the site and injection crew, minimize damage to injection tooling while achieving successful treatment and significant project cost savings.

Sodium or potassium persulfate activated with TSI-FSA™ is injected into the groundwater to produce an in-situ mixture of reactants including persulfate anion $S_2O_8^-$ and the more powerful oxidative radicals $SO_4^{\cdot-}$ and OH^{\cdot} and reductive radical $O_2^{\cdot-}$:



Activated sodium persulfate is commonly used for environmental applications because the persulfate anion is one of the strongest oxidants and yields a higher oxidative power relative to other oxidants as the table below illustrates. Each oxidant is compared relative to chlorine. Activated persulfate also has the advantages of providing both oxidative and reductive pathways for mineralization in a single amendment; the end-product of persulfate reaction is



sulfate, readily supportive of ongoing biological processes and facilitating geochemical and microbial stabilization.

Table I: Reactive Species Associated with Oxidant Chemicals (Huling and Pivetz, 2007)

Reactive Species	Formula	Standard Reduction Potential (V)
Hydroxyl radical	$\text{OH}\cdot$	+2.8
Sulfate radical	$\text{SO}_4\cdot^-$	+2.6
Ozone	O_3	+2.1
Persulfate anion	$\text{S}_2\text{O}_8^{2-}$	+2.1
Hydrogen peroxide	H_2O_2	+1.77
Permanganate anion	MnO_4^-	1.7
Perhydroxyl radical	$\text{HO}_2\cdot$	+1.7
Oxygen	O_2	+1.23
Hydroperoxide anion	HO_2^-	-0.88
Superoxide radical	$\text{O}_2\cdot^-$	-2.4

Reference Huling, S. G. and B. Pivetz. In-Situ Chemical Oxidation--Engineering Issue. EPA/600/R-06/072, 2007.

Multiple radicals result in the rapid destruction of compounds including:

- BTEX
- MTBE
- Petroleum hydrocarbons (TPHs, GRO, DRO)
- Polyaromatic hydrocarbons (PAHs)
- Chlorinated ethenes (TCE, PCE, DCE and vinyl chloride)
- Chlorinated ethanes (TCA and DCA)
- Chlorinated methanes (chloroform and methylene chloride)
- 1,4-dioxane
- Pesticides

Key Communication Points

- Safer activation methods are available.
- The persulfates can be applied at sites where activation is not required such as manufactured gas



- Ideal for the remediation of higher concentration media such as source areas and hot spots
- Lower pH injections result in greater safety for the injection crew
- Provides extended activation of the persulfates in groundwater
- Easy to inject
- Less wear and tear on the driller's equipment since the injectate pH is not lower than 2

Table II: Sodium and Potassium Persulfate Specification and Benefit

Sodium Persulfate Specification	Sodium Persulfate Benefits
Free of Nitrogen	Produced directly from sodium sulfate and not by conversion of ammonia salts
High Solubility (more than 500 g/L at 20°C)	Convenient handling and preparation of aqueous solutions
High Oxidation Potential, Facile Activation	Effective and rapid destruction of contaminants
High Purity	>99%

Potassium Persulfate Specification	Potassium Persulfate Benefits
Free of Nitrogen	Produced directly from potassium salts without the use of ammonium and does thus not contribute to an increase of the nitrogen load in soils
High Fineness, Lower Solubility in Water	Facilitates dosing and allows preparation of aqueous slurries
Increases Longevity After Injection In-Situ	Has a much longer controlled persulfate release and radical generation
High Oxidizing Potential, Facile Activation	Effective sustained destruction of contaminants
High Purity	>99%

Terra Systems can help optimize your comprehensive soil and groundwater remediation treatment train solution. Contact Michael Lee, PhD (mlee@terrasystems.net).