



Advancing the Science of
In Situ Groundwater Remediation



Petroleum Hydrocarbon Remediation Technologies



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Surfactants

Tersus is the worldwide distributor of the leading surfactant technology, *TASK™* (Tersus Advanced Surface Kinetics) and related products, including the patented methods for *in situ* surfactant and chemical oxidation flushing (US Patent Nos. 6913419, 7021863, 7364386, 7,708,496, and 7,677,836). Our anionic surfactant formulations have the unique ability to selectively desorb and liberate sorbed petroleum hydrocarbons from soil and fractured bedrock surfaces allowing for their improved mass recovery and or improved treatment by other remediation techniques.

Supported by nearly three decades of research and formulation testing at the University of Oklahoma, *TASK™* addresses a wide range of applications related to hydrocarbon contamination, including:

- *In situ* soil and groundwater remediation
- Pump and treat enhancement
- Subsurface delivery systems and equipment
- Direct Injection
- *Ex situ* soil washing
- Emergency spill clean-up
- Equipment and tank cleaning
- Sludge removal
- Pipeline cleaning

Benefits

Our site-specific surfactant blends provide considerable advantages.

- Dramatic reduction in cost
- Minimal surfactant mass – usually 0.5 to 0.9 weight percent
- 1 to 1.4 pore volumes for up to 95% mass removal
- No creation of a stable-emulsion, which dramatically reduces treatment costs – the oil separates from the water in a holding tank in less than 30 minutes
- Easy to handle waste stream
- Any surfactants remaining in the subsurface are biodegradable
- Optimization gives lowest interfacial tension (IFT), which allows best recovery

Soil Column Testing		
Surfactant (Volume %)	Pore Volumes Injected	NAPL Recovery (%)
<i>TASK™</i> (1.6%)*	1	93
Product X (4%)	1	59
Product Y (4%)	1	18
Product Z (4%)	1	48
*optimized for Groundwater NAPL		

Laboratory Treatability Studies

Tersus optimizes surfactant systems for each site's geochemistry and NAPL. The treatability study includes phase behavior studies to determine the optimum salinity for an ultra-low interfacial tension (IFT), which in turn enables NAPL mobilization by capillary displacement. The service also includes surfactant/groundwater and surfactant/soil interaction studies to assure that the surfactant system remains active at aquifer conditions. Ultimately, column tests determine the optimum injection strategy and required volumes of post-surfactant recycled ground water injection.



Subsurface Delivery Systems and Equipment

Tersus offers additive injection and groundwater recirculation systems for pilot, short or long-term projects. Customized leases and terms allow you to meet project budgets.

On-Site Field Support

Tersus engages with clients to adequately dose our products and design the project. Our team of engineers, scientists and field support personnel can provide the following resources:

- Scientific Advisors at the University of Oklahoma and Clemson University
- Laboratory Resources from the Applied Surfactant Laboratory at OU
- Laboratory Resources from SiREM Laboratories in Guelph, ON



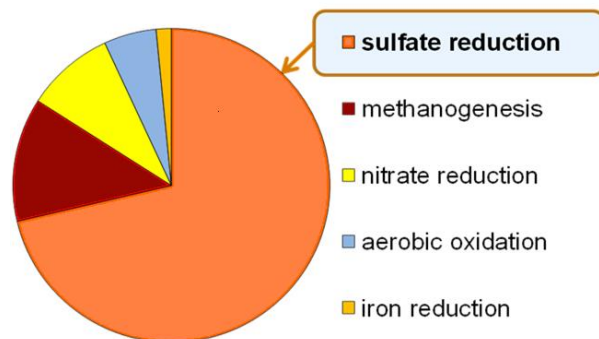
Engaging Tersus to support your field effort improves likelihood of success while minimizing the risks associated with managing complex soil and groundwater remediation projects.

Enhancing Anaerobic Bioremediation

Enhanced aerobic bioremediation technologies such as air sparging or the use of oxygen releasing compounds such as *TersOx™* are commonly used to accelerate naturally occurring *in situ* bioremediation of petroleum hydrocarbons and fuel oxygenates such as MTBE and TBA by indigenous microorganisms. However, oxygen depletes fast and these aerobic indigenous microorganisms often become out populated, not functioning well particularly in high contaminant concentrations areas. Moreover, the oxygen technologies have to overcome anaerobic conditions before becoming effective.

Significance of Sulfate

Sulfate reduction is the predominant electron accepting process for the degradation of hydrocarbons



In fact, sulfate reduction and methanogenesis are the dominant natural degradation processes at most sites. Adding oxygen to the anaerobic portion of the plume may thus be disadvantageous to these processes.

Nutrisulfate® stimulates biodegradation by providing a soluble, readily available electron acceptor solution. In the presence of elevated sulfate, anaerobic groundwater bacteria use BTEX, MTBE and other petroleum hydrocarbons for carbon and energy while mineralizing the hydrocarbons to carbon dioxide and water. Sulfate addition enhances natural conditions and reduces the carbon footprint when compared to conventional remediation.

Nutrisulfate® is a high sulfate metabolic supplement designed to enhance the kinetics and efficiency of microbial systems specifically related to bioremediation of BTEX, MTBE, TBA and other petroleum hydrocarbons. The increase in kinetics and efficiency decreases remediation times and reduces the amount of substrate / amendment required.

Sulfate Enhanced Bioremediation



Benefits & Features

- Demonstrated effectiveness on BTEX, MTBE, and TBA
- No adverse effects
- Clean, low-cost, non-disruptive application (e.g., direct-push, wells and excavations)
- Aqueous solution for easy injection and distribution
- Maintains pH neutral
- Nutrient-enhanced for anaerobic bacteria
- Enhances abiotic bioremediation
- Decreases overall remediation time
- Reduces the amount of substrate required
- Remedy will be faster, better and cheaper

***In Situ* Sorption and Biodegradation**

Combining Powdered Activated Carbon with an Electron Acceptor to Stimulate Biodegradation

Now available for both Aerobic and Anaerobic Bioremediation

Designed to address the challenges in soil and groundwater remediation, *NutriBind®* is a powdered reagent that once applied delivers rapid contaminant concentration reduction (days) combined with accelerated bioremediation. When mixed with water, the resulting slurry contains elevated electron acceptors to increase efficiency of electron donor (hydrocarbon contaminants) utilization.

NutriBind® has a dual function. It immediately binds and immobilizes contaminants in soil and groundwater, quickly removing them from the mobile phase. The high surface area provides a matrix favorable for microbial colonization and growth. Treatment of the sorbed contaminants is further accomplished through enhanced aerobic bioremediation or sulfate enhanced bioremediation, depending on the formulation selected.

NutriBind® stimulates biodegradation by providing a readily available electron acceptor, *TersOx™* for enhanced aerobic bioremediation or *Nutrisulfate®* for sulfate enhanced bioremediation. In the presence of elevated electron acceptors, groundwater bacteria use BTEX, MTBE and other petroleum hydrocarbons for carbon and energy while mineralizing the hydrocarbons to carbon dioxide and water. Oxygen (aerobic bioremediation) or sulfate (anaerobic bioremediation) addition enhances natural conditions and reduces the carbon footprint when compared to conventional remediation.

Features & Benefits

- *NutriBind®* treats both water and soil
- Immediate solution with a predictable end result
- Rapidly reduces dissolved-phase plumes in days/weeks
- Stops plume migration and protects sensitive receptors
- Addresses matrix back diffusion
- Cost effective treatment alternative
- Available with Kosher certified powdered adsorbent media that meets NSF/ANSI Standard

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NutriBind®

Enhanced Remediation Device

Waterloo Emitter™

The Waterloo Emitter is a simple, low cost device designed for the controlled and uniform release of oxygen, or other bio-enhancing amendments, to encourage and sustain the growth of microorganisms required for *in situ* bioremediation of contaminated groundwater.

The patented technology (U.S. Patent # 5,605,634) enables steady, direct diffusion of oxygen into an aquifer through pressurized silicone or LDPE tubing. Continuous, consistent release of oxygen into the tubing creates the ideal concentration gradient driving this passive system, without 'bubbling off' excess oxygen.

Emitters are ideal for the bioremediation of BTEX and MTBE using oxygen. The diffusive process provides immediate bioavailability of molecular oxygen for aerobic biodegradation enhancement; therefore, no loss of the amendment gas occurs. The Waterloo Emitter can also encourage desirable abiotic reactions (pH adjustment, hydrolysis, etc.).



Simple Versatile System

Waterloo Emitters are available to fit 2", 4" and 6" (50 mm, 100 mm and 150 mm) wells. They can be installed in open wells, or they can be permanently installed with sand packs in boreholes or trenches. The 51" (130 cm) long Waterloo Emitters can be installed individually or stacked one on top of another, to ensure full coverage of the contaminant plume. They are also effective in horizontal applications.

Because there is no minimum hydraulic head required, the Emitters are effective at any depth below water. When used in conjunction with packers and/or circulating pumps, the radius of influence is increased.

The Waterloo Emitter's unique diffusive technology allows for the use of almost any chemical as an amendment to treat contaminated groundwater. The PVC frame accommodates the insertion of monitoring or sampling devices for observing groundwater conditions during the remediation process.

Advantages

- Low cost
- Steady release for constant microbial activity
- Easy installation and removal
- Minimal maintenance and operating effort
- No amendment loss due to 'bubbling'
- No hazardous substances introduced or produced
- No slurry to mix, handle or inject
- No electricity required

Inorganic Peroxygen for Enhanced Aerobic Bioremediation

TersOx™ Powder and Tablet

TersOx™ is a specially formulated calcium peroxide that produces a controlled release of molecular oxygen designed to assist in the aerobic bioremediation of hydrocarbons in soil and groundwater. *TersOx™* stimulates natural degradation of petroleum hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes (BTEX). This is not a chemical oxidation product. The high ratio of O₂ in *TersOx™* provides a long-term oxygen source for up to 12 months upon hydration under ideal conditions. This sustained release of oxygen stimulates indigenous bacteria, accelerates bioactivity, and promotes increased contaminant removal.



TersOx™ Tablets conveniently packaged in 25 kg boxes with 40 boxes per pallet.

TersOx™ Features & Benefits

- *Controlled release of molecular oxygen to support aerobic microbial biodegradation*
- *Long-term source of oxygen to the subsurface*
- *Clean, low-cost, non-disruptive application*
- *No operations and maintenance costs*
- *Complimentary site evaluation from Tersus Environmental*



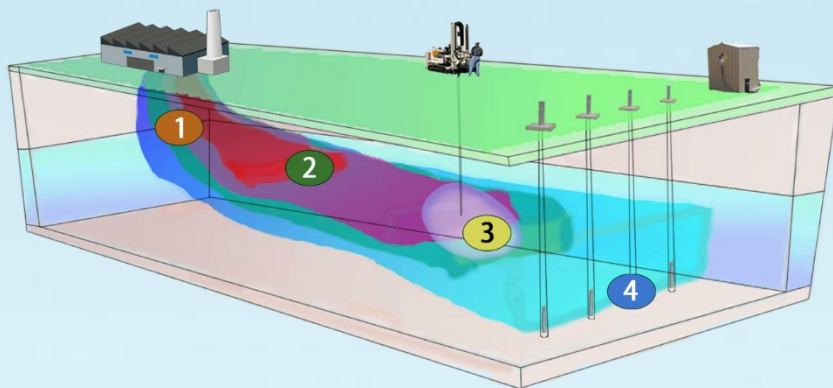
Activated and Controlled Exothermic (ACE) ISCO *Modulated TersOx™ Liquid*

Modulated TersOx™ Liquid is formulated to slowly generate hydroxyl free radicals that exhausts oxygen demand, eliminates high contaminant inhibition, and enhances bioremediation performance by reducing lag times and directs biological activity towards contaminant breakdown. This powerful and non-selective preliminary reactions can oxidize a wide variety of organic contaminants into non-regulated compounds, yet it is extremely stable to be

blended as one product for subsurface injection, above ground for safety, for long-lasting effects below ground, and to allow contact where needed.

Modulated TersOx™ Liquid offers potency, stability, and persistence of biological polishing. Our proprietary catalyst will slowly and steadily activate *TersOx™ Liquid*, avoiding excessive and inefficient heat and pressure problems associated with conventional ISCO approaches. The performance of standard oxygen releasing *TersOx™* and *TersOx™ Nutrients™* following a *Modulated TersOx™ Liquid* event significantly improves, allowing overall project goal to be met sooner and permanently, while keeping costs low.

Petroleum Hydrocarbons Remediation Technologies



Vadose Zone Remediation

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- *Modulated TersOx™ Liquid*
- Peroxygens (*TersOx™ Powder* and *Granular*)
- *TersOx™ Nutrients* (Slow Release, Quit Release and Custom Formulations)
- *TersOx™ Microbe*
- *NutriBind®*

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Saturated Zone LNAPL Remediation

- *TASK™* (Tersus Advanced Surface Kinetics)

Dissolved Contaminant

Activated and Controlled Exothermic (ACE) ISCO

- *Modulated TersOx™ Liquid*

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Dissolved Contaminant Anaerobic Remediation

- *Nutrisulfate®*

In Situ Sorption and Biodegradation

- *NutriBind®*

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Dissolved Contaminant Aerobic Remediation

- Peroxygens (*TersOx™ Powder* and *Tablet*)
- *TersOx™ Nutrients* (Slow Release, Quit Release and Custom Formulations)
- *TersOx™ Microbe*
- Oxygen delivery systems (*Waterloo Emitter™*)

Sales and Technical Support



For every zone of your plume, we've got you covered!
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