Terra Systems INCORPORATED

60% SRS®-C Custom Small or Large Droplet Emulsified Vegetable Oil (EVO) Substrate

United States Patent #RE40,448

Terra Systems SRS®-C is a customer designed emulsified vegetable oil formulation based on Terra Systems patented family of SRS® substrates. Previous custom customer formulations are outlined in Table I below.

Table I: Common SRS®-C Custom Emulsified Vegetable Oil Substrate Requests

Customer Formulation	Benefit
A mix of 75% SRS®-SD small droplet EVO and 25% SRS®-FR large droplet EVO	Permeable reactive barrier (PRB) with wells on 75 feet spacing's across the down gradient edge of the plume at the property boundary. A combination SRS®-SD and SRS® -FR were used to achieve the maximum radius of influence with the SRS®-SD and the longevity in the PRB with the SRS® -FR.
A mix of 50% SRS®-SD small droplet EVO and 50% SRS®-FR large droplet EVO	A 50/50 combination of SRS®-SD and SRS® -FR were used to address higher concentrations of contaminants of concern (COCs) near the point of injection (SRS®-FR) and the diffuse plume was addressed with SRS®-SD, which radiated further from the point of injection.
A mix of 25% SRS®-SD small droplet EVO and 75% SRS®-FR large droplet EVO	Source area injections of a 25/75 combination of SRS®-SD and SRS® -FR achieved maximum retention near the highest contaminant concentration while still dealing with diffuse edges of the plume.
Addition of 2 – 8 g/L of sodium bicarbonate	Counter the increase in aquifer pH due to the acids produced during the fermentation process
Increase the amount of sodium lactate to 5, 6 or 7%	Additional sodium lactate a fast release source of carbon and hydrogen was added and rapidly generated anaerobic conditions that the consultant used to convince his client to go full scale.
Increase the quantity of Vitamin B_{12} from 250 µg/L to 500, 750 or 1,000 µg/L	He et al. 2007 demonstrated Vitamin B_{12} to be an important micronutrient to enhance dechlorination activity.
Increase the quantity of Proprietary Food Grade Nutrients from 0.35% to 1, 2, 3 or 4%	Nutrients have been demonstrated to support the growth of the anaerobic microbial population.

The anaerobic bioremediation process uses native or introduced microorganisms (*Dehalococcoides*) to degrade chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to innocuous end products including ethene and ethane. Terra Systems patented *Family* of **SRS®** Emulsified Vegetable Oil Substrates are added to the groundwater to rapidly generate reducing conditions and provide the necessary carbon and hydrogen to support biodegradation of the chlorinated solvents. Terra Systems ability to leverage its core

competencies in R&D, laboratory treatability studies and manufacturing allows the PM to choose or design the right product for their needs and reduces the likelihood of "*trying to fit a square peg into a round hole*".

Table II: Basic Building Blocks for Terra Systems patented SRS® Family of Emulsified Vegetable Oil Substrates

Ingredient	Percent	Description	Benefit
Food Grade U.S. Grown Soybean Oil	60%	Terra Systems operates its own state-of-the-art manufacturing facility.	Long lasting slow release source of carbon and hydrogen, consistent product quality, uniform droplet size, neutral pH, QA/QC lab on floor to check product before shipment.
Food Grade Sodium or Potassium Lactate	4%	Rapidly biodegradable soluble substrate	Fast release source of carbon and hydrogen to rapidly generate anaerobic conditions
Proprietary Food Grade Nutrients	<1%	Proprietary organic and inorganic nutrients such as yeast extract, nitrogen and phosphorus.	Nutrients have been demonstrated to support the growth of the anaerobic microbial population.
Proprietary Food Grade Emulsifiers and Preservatives	7.5%	Proprietary nonionic or anionic emulsifiers	Maximum radius of influence (nonionic emulsifier) or maximum retention the aquifer (anionic emulsifier)
Vitamin B_{12}	<1%	At least 250 µg/L of Vitamin B_{12}	He et al. 2007 demonstrated Vitamin B_{12} to be an important micronutrient to enhance dechlorination activity with 25 µg/L providing maximum stimulation
Median Oil Droplet Size (microns)	NA	0.6 µm for SRS®-SD or 5 µm for SRS®-FRL	Maximum radius of influence (0.6 µm droplet) or retention in the aquifer (5 µm droplet)
pH	6.5 - 7	6.5 - 7	Optimum microbial activity

Customers: SRS®-C is used by environmental consultants who understand that not all aquifers are created equal. The ability to work with Terra Systems to develop a custom product for a particularly challenging remediation site or to tweak an existing formulation provides the PM and client greater flexibility, control and improves the chances of success.

Manufactured vs. Field Emulsion

In the early days of in-situ bioremediation when Terra Systems first patented the technology, it was common to bring the water, emulsifiers, oil, and other ingredients to the site and using trash or other pumps to mix the ingredients together to form an emulsion. It soon became apparent that poor emulsion consistency and a broad range of droplet sizes resulted in inadequate and uneven distribution when injected. This resulted in higher long-term costs due to higher reinjection frequency and higher substrate volumes to adequately make contact with the COCs.

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Don't be "***penny wise and pound foolish***".

Consider:

- ✓ The labor and equipment time and cost of mixing in the field.
- ✓ The need to mix the nutrients and Vitamin B_{12} longer to achieve consistency.
- ✓ The cost of inadequate distribution due to droplet size and emulsion inconsistency
- ✓ The inability to accurately determine if you have 100% emulsification.
- ✓ The lack of QA/QC in the field

- Terra Systems owns and operates a state of the art US based manufacturing plant with an in-house quality control laboratory for strict quality assurance of the emulsion, droplet size and pH.
- SRS®-C arrives at the site "***injection ready***" with all the ingredients that you helped design – soy bean oil, proprietary reductant, Vitamin B_{12}, proprietary nutrients, sodium or potassium lactate and anionic or nonionic emulsifier(s) already blended together.

The development cycle for SRS®-C may include one or more of the following based on input from the PM.

- ✓ Literature research
- ✓ Formulation design
- ✓ Laboratory testing of the formulations
- ✓ A treatability study using groundwater and saturated soil from the actual site.
- ✓ A pilot test

- SRS®-C optimizes the naturally occurring biodegradation system by supplying the rate limiting factor (in this case hydrogen) in the degradation of CVOC's, certain pesticides/herbicides, perchlorate, and immobilization of certain metals (hexavalent chromium, molybdenum, selenium, and some radionucleides).
- SRS®-C can be manufactured in our plant with a **small droplet size** of **0.6 μm** and a nonionic **emulsifier** for maximum radius of influence in the subsurface or with a large droplet size of **5 μm** and a **anionic emulsifier** for maximum retention in the subsurface.
- Terra Systems holds United States Patent #**RE40,448** for the use of emulsified vegetable oil for remediation of chlorinated solvents.
- The soy bean oil is grown in the United States and provides a **slow release** biodegradable carbon source, which promotes long-term biological activity.

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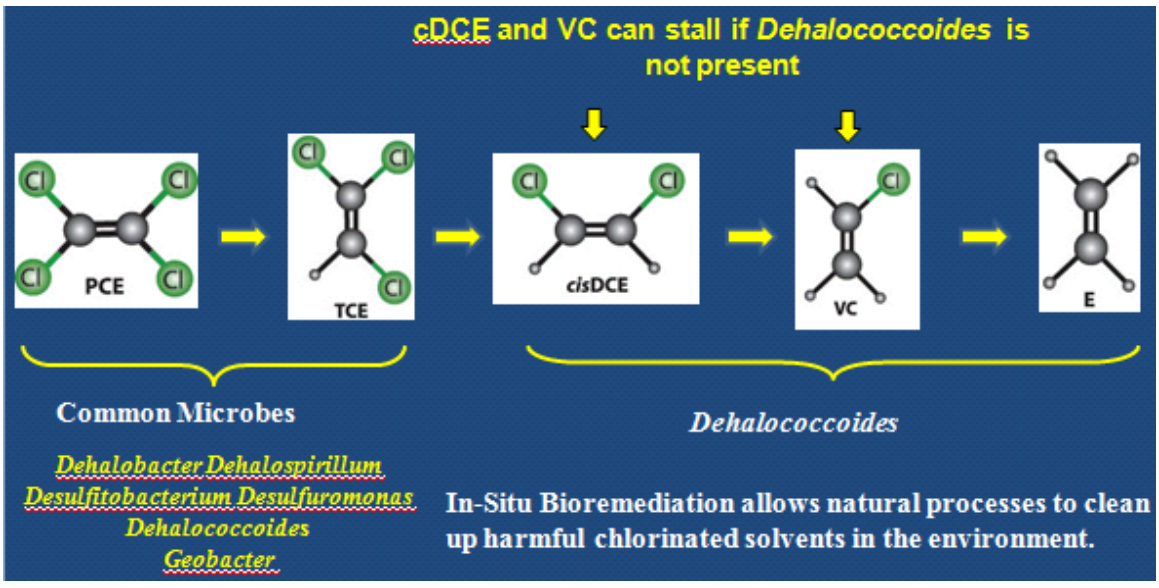
- SRS®-C comes **standard** with **biostimulating vitamins** like Vitamin $B_{12,}$ which He et al. 2007 demonstrated is an important micronutrient to enhance dechlorination activity.
- SRS®-C contains proprietary organic and inorganic nutrients such as yeast extract, nitrogen and phosphorus, which have been demonstrated to support the growth of the anaerobic microbial population.
- SRS®-C comes with **at least 4% sodium** or **potassium lactate** a quick release biodegradable substrate, which helps to "*jump start*" bacterial growth.
- SRS®-C emulsified vegetable oil substrate has been validated by the Florida DEP, California Water Board and others.
- SRS®-C contains only non-toxic food grade materials, which results in green, sustainable remediation.
- Potassium Lactate can be substituted for Sodium Lactate if required in California or Florida.

Packaging: Terra Systems patented SRS®-C can be shipped in 5-gallon buckets, 55-gallon drums, 275-gallon IBC totes, 275-gallon cardboard totes or bulk tankers.

If the *Dehalococcoides* are not present or are in small numbers Terra Systems **TSI DC®** Bioaugmentation Culture can also be injected.



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