60% SRS®-SD Small Droplet Emulsified Vegetable Oil (EVO) Substrate for Maximum Radius of Influence

United States Patent #RE40,448

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 **SRS®-SD** Small Droplet Emulsified Vegetable Oil Substrate includes a **nonionic emulsifier** (does not have a charge), which does not readily stick to soil particles and is specifically designed when maximum radius of influence in the formation is key to making contact with the bacteria. It is is added to the groundwater to rapidly generate reducing conditions and provide the necessary carbon and hydrogen to support biodegradation of the chlorinated solvents.

Table I: SRS®-SD Small Droplet Emulsified Vegetable Oil Substrate Specifications

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 emulsifier	Maximum radius of influence due to small droplet size and nonionic emulsifier in moderate to fine sand, silt and clay aquifers
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	Maximum radius of influence due to small droplet size and nonionic emulsifier in moderate to fine sand, silt and clay aquifers
pH	6.5 - 7	6.5 - 7	Optimum microbial activity

Application: Terra Systems **patented**, nutrient enriched, proven slow release SRS®-SD **small droplet** emulsified vegetable oil substrate with a **nonionic emulsifier** is used when a long lasting carbon substrate is desired that provides maximum radius of influence in moderate to fine sand, silt and clay aquifers, which increases the distance between injection points and reduces the frequency of reinjection. The groundwater flow-rate is typically less than 180 feet/year. SRS®-SD does not stick to soil particles and is specifically designed when radius of influence in the formation is key to making contact with the bacteria.

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Customers: SRS®-SD is used extensively by consultants working with current and former drycleaners, semiconductor plants and private firms and the Air Force, DOD, Navy, and EPA to cost effectively remediate chlorinated solvent sites. SRS®-SD releases bio-available hydrogen over a period of 3 to 5 years thus enhancing the long-term anaerobic biodegradation of the chlorinated solvents and reducing the frequency of reinjection.

Manufactured vs. Field Emulsion

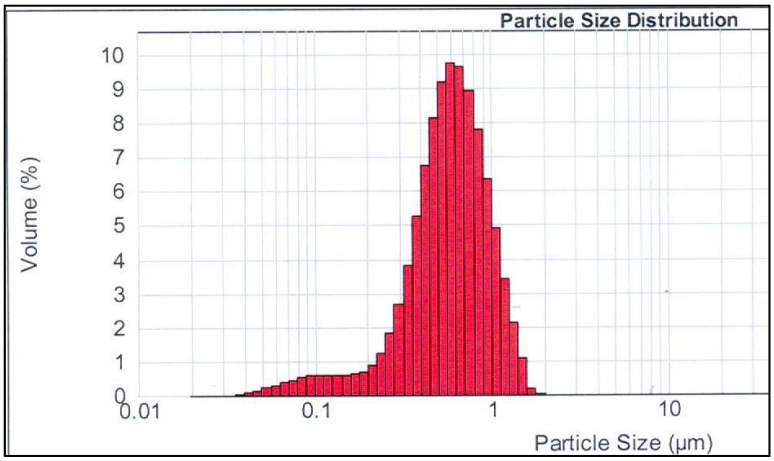
In the early days of in-situ bioremediation when Terra Systems first patented the technology, it was common to bring the water, emulsifiers, oil, and other ingredients to the site and using trash or other pumps to mix the ingredients together to form an emulsion. It soon became apparent that poor emulsion 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 COC.

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®-SD arrives at the site "***injection ready***" with all the ingredients – Vitamin B_{12}, proprietary nutrients, sodium or potassium lactate and anionic emulsifier(s) already blended together.
- At the PM's request Terra Systems will blend 2-8 g/L of sodium bicarbonate into the SRS®-SD during manufacturing to counter the acids produced during the fermentation process in the aquifer. This is especially beneficial for marginal pH aquifers of pH 5 – 6.



A Digital Microscope is connected to a laptop computer with proprietary "***Droplet Size Calculation Software***" which allows us to calculate the "***mean***" droplet size for each batch of SRS®-SD before transferring to a bucket, drum, tote or tanker for shipment to the customer

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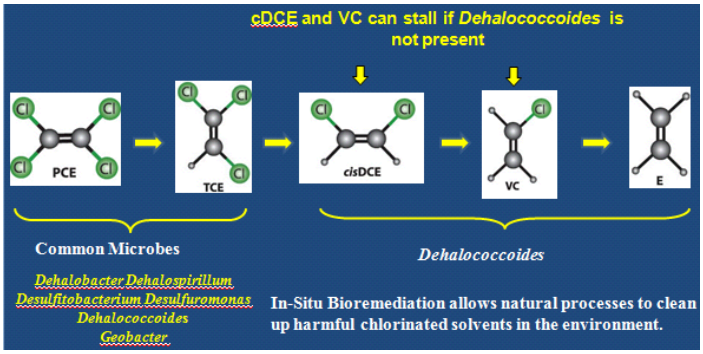
- SRS®-SD optimizes the naturally occurring biodegradation system by supplying the rate limiting factor (in this case hydrogen) in the degradation of CVOC's, certain pesticides/herbicides, perchlorate, and immobilization of certain metals (hexavalent chromium, molybdenum, selenium, and some radionuclides).
- The **small droplet size** of **0.6 µm** combined with the **neutral surface charge** on the droplets results in a higher radius of influence 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.
- SRS®-SD comes **standard** with **biostimulating vitamins** like Vitamin $B_{12,}$ which He et al. 2007 demonstrated is an important micronutrient to enhance dechlorination activity.
- SRS®-SD 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®-SD comes with **at least 4% sodium** or **potassium lactate** a quick release biodegradable substrate, which helps to "*jump start*" bacterial growth.
- SRS®-SD emulsified vegetable oil substrate has been validated by the Florida DEP, California Water Board and others.
- SRS®-SD contains only non-toxic food grade materials, which results in green, sustainable remediation.

Packaging: Terra Systems patented SRS®-SD 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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