



Patented *Injection Ready* 60% SRS[®]-C Custom Small or Large Droplet Emulsified Vegetable Oil (EVO) Substrate

United States Patent #RE40,448

Terra Systems patented "*injection ready*" **SRS[®]-C** small or large droplet Emulsified Vegetable Oil Substrate is added to the groundwater to rapidly generate reducing conditions and provide the necessary carbon and hydrogen to support native or introduced microorganisms (*Dehalococcoides*) for the biodegradation of chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to innocuous end products including ethene and ethane.

Key Communication Points

- SRS[®]-C is a customer designed emulsified vegetable oil formulation based on Terra Systems patented family of SRS[®] substrates.
- Can be designed with a small (0.6 µm) droplet size for optimum substrate distribution or a large droplet (5 µm) for optimum retention for PRB's, fast flowing aquifers and nearby waterways. Different mixes of droplet sizes can be produced and mixed together.
- Typical formulations provide 73% fermentable carbon
- Typical formulations have >98% biobased content
- Can include sodium or potassium lactate to kick-start the anaerobic degradation process, nutrients and Vitamin B₁₂, a micronutrient, which *He et al. 2007* demonstrated is an important micronutrient to enhance dechlorination activity.
- It arrives as a homogenous *injection ready substrate*, which results in lower field labor costs from inefficient field mixing.
- Proven effective with PCE, TCE, TECA, DNAPL (Sabre Project), Perchlorate, TCA, Cr⁶⁺, TNT, Uranium and Nitrate at military installations (Andrews AFB, Dover AFB, Beale AFB, Ft. Gillem, Fort Dix, Camp Bullis, Aberdeen Proving Ground, etc.), dry cleaners, semiconductor manufacturers, fabricators and manufacturing firms that use and clean metal parts (air conditioners, dishwashers, etc.).

Table I: SRS[®]-C Custom Emulsified Vegetable Oil Substrate Ideas

Customer Formulation	Benefit
A mix of 75% SRS [®] -SD small droplet EVO and 25% SRS [®] -FRL 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 [®] -FRL were used to achieve the maximum radius of influence with the SRS [®] -SD and the longevity in the PRB with the SRS [®] -FRL.
A mix of 50% SRS [®] -SD small droplet EVO and 50% SRS [®] -FRL large droplet EVO	A 50/50 combination of SRS [®] -SD and SRS [®] -FRL were used to address higher concentrations of contaminants of concern (COCs) near the point of injection (SRS [®] -FRL) and the diffuse plume was addressed with SRS [®] -SD, which radiated further from

130 Hickman Road – Suite 1 – Claymont – Delaware – 19703

For More Information Call Michael Free at 302-798-9553 or Email: mfree@terrasystems.net



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	the point of injection.
A mix of 25% SRS [®] -SD small droplet EVO and 75% SRS [®] -FRL large droplet EVO	Source area injections of a 25/75 combination of SRS [®] -SD and SRS [®] -FRL achieved maximum retention near the highest contaminant concentration while still dealing with diffuse edges of the plume.
Increase the amount of sodium lactate up to 6%	Additional sodium lactate as 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 0.4% to 1, 2, 3 or 4%	Nutrients have been demonstrated to support the growth of the anaerobic microbial population.
Addition of ferrous gluconate	

Injection Ready Manufactured Emulsion

Terra Systems *Family* of patented SRS[®] emulsified vegetable oil substrates

- Arrives injection ready
- Arrives at the site with a zero-carbon footprint
- Certified under the USDA Biopreferred Program with >98% biobased content

Result: A consistent emulsified vegetable oil substrate, which arrives *ready to inject* for maximum distribution in the aquifer.

It Avoids Field Mixing and Their Hidden Costs Such As:

- The cost of inadequate distribution due to variable 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 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”.

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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



Table II: Basic Building Blocks for Terra Systems patented SRS[®] Family of Emulsified Vegetable Oil Substrates – Can be Adjusted Based Upon Client’s Needs

Ingredient	Percent	Description	Benefit
Food Grade U.S. Grown Soybean Oil	60%	Locally sourced soybean oil.	Long lasting slow release source of carbon and hydrogen.
Food Grade Soluble Substrate	5.5%	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, Preservatives and other Organics	7.5%	Proprietary nonionic emulsifier and other organics	A small droplet (0.6 μm) for maximum radius of influence due to small droplet size and nonionic emulsifier in moderate to fine sand, silt and clay aquifers or a large droplet (5 μm) and anionic emulsifier for maximum retention in PRB's, fast flowing aquifers and nearby waterways.
Vitamin B ₁₂	<1%	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 or 5 μm	A small droplet (0.6 μm) for maximum radius of influence due to small droplet size and nonionic emulsifier in moderate to fine sand, silt and clay aquifers or a large droplet (5 μm) and anionic emulsifier for maximum retention in

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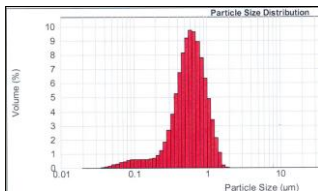


			PRB's, fast flowing aquifers and nearby waterways.
pH	6.0 - 7	6.0 - 7	Optimum microbial activity
Organic Carbon (wt%)	73%		60% soybean oil and 13% from lactate, nutrients, emulsifiers and VB ₁₂
Zero Carbon Footprint	0%		Certified by The CarbonNeutral Co., SRS [®] has a carbon neutral footprint when it arrives at the job site.
Biobased Content	98%		Certified under USDA Biopreferred Program

Terra Systems QA/QC

Terra Systems owns and operates a state-of-the-art US based "just-in-time" manufacturing plant with an in-house quality control laboratory for strict quality assurance of the emulsion, droplet size and pH. A Microscope with "Droplet Size Calculation Software" calculates the "mean" droplet size for each batch of SRS[®] before we transfer to a bucket, drum, tote or tanker for shipment to the customer. With every shipment, we include a QA/QC sheet for the actual batch that the customer receives. Included are:

- **Date Manufactured:** Freshly manufactured products have a longer shelf life in the field. Avoid buying substrates that have been stored for >1 month as fermentation can start and the pH will be negatively impacted.
- **pH:** We provide the pH of the product the day it is shipped
- **Droplet Size:** is a key measure of how effective the client can distribute the substrate in the sub-surface. The smaller the droplet, the more effective the distribution and ease of injection.



- **Lot#'s for all the ingredients:** This is especially useful if the driller accidentally hits a discharge pipe and the consultant needs to provide documentary evidence of what exactly was injected to the regulatory agency. All of our ingredients are GRAS (generally recognized as safe).

Packaging: Terra Systems patented SRS[®] Family of EVO substrates can be shipped in 5-gallon buckets, 55-gallon drums, 275-gallon IBC totes, 275-gallon cardboard totes or bulk tankers.

