What are the differences among surfactants used for in-situ applications?

Surfactants are interesting compounds that have an affinity for water and oils. We commonly find surfactants in household cleaners, detergents, shampoos, and other cleaning agents. Although there are thousands of surfactants, less than a hundred have been investigated for use in environmental applications. Important differences among surfactants are their molecular structures and charge of the molecule when in solution, which affect their aggregation properties. Typically, anionic surfactants have a great capacity to lower the interfacial tension between water and oil. Further, you lose little anionic surfactant to matrix demand.

Can surfactant flushing achieve maximum contaminant levels (MCLs)?

Surfactant flushing removes non-aqueous phase liquids (NAPL) from the subsurface. Other technologies, such as bioremediation and chemical oxidation, are appropriate for aqueous phase applications. Typically, you would use surfactants to remove oils, followed by other technologies to reach MCLs.

Why is alcohol used?

During surfactant-enhanced aquifer remediation (SEAR), we use alcohols to stabilize the surfactant molecules in solution. If the surfactant precipitates from solution, the resulting gels and crystals would be too viscous to pump through the aquifer.

Why is salt used?

Many surfactant vendors seek to create oil in water emulsions to help mobilize the NAPL. We add electrolytes to achieve an ultra-low interfacial tension; that is, to optimize the NAPL formulation, while minimizing the amount of emulsions.

Why do surfactant vendors seek to dissolve NAPLs?

It is extremely difficult to move NAPL in a water matrix. Most surfactant vendors seek to solubilize the NAPL by creating an emulsion. This works; however, it requires lots of surfactant and the resulting emulsion is expensive to treat. Instead, the approach we use minimizes the amount of emulsion produced and simply makes the oil more slippery. The cost advantages are significant: You use far less surfactant and your effluent treatment costs are considerably lower.

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What concentrations of surfactants are used?

Concentrations vary with the contaminant, matrix geochemistry and goals, and objectives of the remedy. Typically, TASK formulations are well below 1 % by weight.

How is TASK™ injected?

TASK comes in concentrated form. You will need to dilute it prior to injection. The ratio varies depending on the formulation (10:1 to 20:1). We typically recommend pumping it from a drum or tote to a mixing tank where it is diluted and then gravity fed or pumped into wells. Flow meters can measure the amount injected.

How does source zone characterization for surfactant flushing differ from dissolved phase plume characterization?

Delineating NAPL distribution can be quite challenging, as it is often quite heterogeneous. It is not unusual to see blobs of residual (non-mobile) NAPL.

How do you know when you've gotten enough surfactant out of the ground to terminate a surfactant flood?

After using surfactants to flood the targeted zone, you inject water to remove the surfactants and contaminants. Generally the ratio of water to surfactant flush is 2:1. At the end of the water injection, any surfactants remaining in the aquifer should be below the critical micelle concentration; that is, they will no longer improve the mobility of residual NAPL.

How do you prevent surfactants from escaping the targeted treatment zone during a surfactant flood?

As is true with any advective flow based technology, contact and hydraulic control are critical. Important parameters include properly locating injection, extraction and hydraulic control wells and maintaining proper flow rates. Extraction rates are typically higher than injection rates.

Why is modeling needed to select appropriate flow rates for the injection and extraction?

Subsurface systems are highly heterogeneous. You need robust models to insure NAPL and surfactant capture.

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Can I use my existing pump and treat or extraction wells?

The hydraulic efficiency of injection wells and the proper placement of the screened intervals are important elements in surfactant flood designs. If you can confirm that the existing wells meet the flood design, using these wells should be appropriate. Although permitting is not required, extraction wells used for *in-situ* surfactant flooding should also meet these criteria.

Can surfactants be used for dense non-aqueous phase liquids?

While the chemistry will work, you should be very cautious when deploying any mobilization technology for DNAPLs. Designing and implementing a DNAPL removal operation is a complex endeavor, as you must avoid uncontrolled vertical and horizontal migration of contamination. A thorough understanding of the subsurface environment, multiphase fluid flow, and the physical processes being employed is required to minimize remediation failure and avoid contaminating previously uncontaminated portions of the aquifer. Our clients often choose emulsified zero valent iron (eZVI) to remediate chlorinated DNAPLs.

I have 25 mg/L TCE in several wells at my site. Can surfactants help me reach remediation goals?

Surfactants are appropriate for NAPL removal only. If you have TCE DNAPL, surfactants can remove them. Please see the cautionary note above.

Will surfactants inhibit biodegradation?

Most surfactants will, at least temporarily, inhibit biological activity. That said, many surfactants used for in-situ NAPL removal are food or cosmetic grade chemicals. Laboratory (treatability) studies can elucidate how surfactants would impact the growth of microorganisms at the site.

Will surfactants be lost to the soils?

Many soil types will have an attraction to non-ionic surfactants. As TASK is anionic (negatively charged), there will be little loss to matrix demand.

Please describe the effluent treatment process.

Surfactants extracted from the subsurface will be significantly diluted and laden with contaminant; thus, the primary task is to separate the contaminant from the surfactant. Gravity separation can be used to remove mobilized NAPL from the surfactant and water, while solubilized NAPL can be removed by a variety of treatment

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processes depending on contaminant properties. Once treated, the extracted surfactant may be delivered to a POTW or recycled in the process.

I have heavy metals contamination at my site as well as NAPL contamination. Can surfactants be used to remove both?

Tersus recommends treatability studies conducted at the University of Oklahoma. Often, the study can help formulate surfactants that mobilize NAPL and metals.

Is a treatability study necessary for my site?

Generally, the purpose of a treatability study is to formulate a surfactant mixture that provides the lowest possible interfacial tension. In other words, the study will allow you to use the least amount of surfactant to reach your remediation goals. If your site is small, the savings in surfactants may not off-set the cost of the treatability study, which usually ranges between $30,000 and $45,000. However, if your site is sufficiently large, the cost savings can be dramatic.

How is interfacial tension measured?

We use a spinning drop tensiometer to measure IFT.

How does Tersus support my efforts?

Tersus provides off the shelf surfactants, surfactants designed for site specific conditions and design and engineering support for the surfactant floods. As the chemistry and implementation requires know-how, the Tersus team is comprised of university professors, system integrators and experienced field implementors.

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