Surfactant-Enhanced Treatment of Oil-Contaminated Soils and Oil-Based Drilling Cuttings – Annual Report

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Title: Surfactant-Enhanced Treatment of Oil-Contaminated Soils and Oil-Based Drill Cuttings – Annual Report
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EPA Project Officer: Bala Krishnan
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Project Amount: $115,053
Research Category: Subsurface remediation with surfactants

Objective(s) of the Research Project: This project seeks to reduce the environmental risk associated with the disposal of oil-laden drill cuttings through the design of a surfactant-based washing process that uses near-CMC levels of surfactants to remove the oil from the surface of the cutting through a combination of roll-up and snap-off detergency. This low surfactant concentration constriction is expected to benefit not only the economic feasibility of the technology but also minimize the potential environmental impact of the surfactant itself.

Progress Summary/ Accomplishments: The following is a list of the main findings of the project in the last year:

1.- Selection of the best surfactant: we performed a series of phase behavior studies, this implied selecting a given concentration (0.025 % active) for all the potential surfactants to be used in the field and obtaining the interfacial tension against the oils of interest (diesel and synthetic alpha olefins) at different levels of electrolyte concentration (see Figure 1). The criteria for selecting the oil was in terms of which of the surfactants systems could obtain the lowest interfacial tension. The result of this experiment shows that surfactant Alfoterra 145-4PO showed the best performance of all the surfactants evaluated.

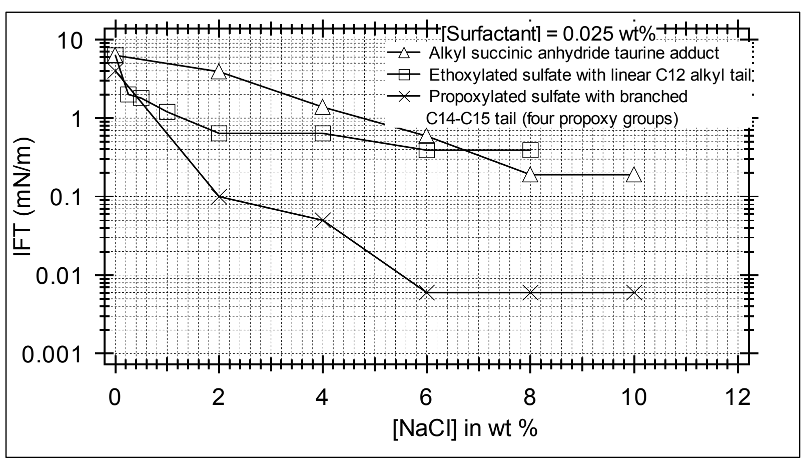

Figure 1: Screening of surfactants based on Interfacial tension studies

2.- Optimization of the formulation: from the work above we selected the surfactant and the electrolyte concentration that offered the lowest interfacial tension, and according with our objectives, the optimization of this formulation required the lowest surfactant concentration that could still hold this ultralow interfacial tensions with the oils of interest. Therefore we measured the interfacial tension of alfoterra against the synthetic alpha olefin, holding the concentration of sodium chloride at 6%. While the concentration of alfoterra could have been as low as 0.01% active, we preferred to stay with 0.1% active. This is the same level of concentration normally used in textile detergency, which suggests that this concentration is not only economic but safe, and it also provides some cushion for surfactant losses without experiencing dramatic changes in interfacial tension.

3.- Washing studies: given the baseline formulation, 0.1% alfoterra 145-4PO, 6% NaCl we performed washing studies of synthetic oil muds and of oil-laden natural media (sandy alluvium form the Canadian river in Norman, OK). These studies showed limited removal for the drill cuttings but a substantial removal for the river alluvium, in both cases better than water alone.

4.- Investigation of surfactant fate: measurements of interfacial tension after washing reflected that, in the case of the alfoterra formulation, the interfacial tension increased from levels of 10^{-3} dyn/cm to 10^{-1} dyn/cm, while for the case of the river alluvium remained constant. Further studies of the surfactant concentration after wash showed that more than 90% of the surfactant was lost to adsorption/precipitation on the surface of the cuttings. Later we found significant amounts of calcium ions deposited by the mud (formulated with $CaCl_2$) on the surface of the cuttings that were responsible for the losses of the surfactant. We introduced a typical hardness (calcium ions) binding additive (builder), sodium metasilicate in the formulation at different levels of concentration finding that 13% of Na_2SiO_3 (and no sodium chloride) can obtain and maintain the low interfacial tension throughout the washing process and reduce the surfactant adsorption to 10% or less. In this conditions we significantly improved the removal of oil from the cuttings.

5.- Kinetic investigation: the initial oil content in drill cuttings can be up to 20% based on the mass of dry cuttings, and after washing and centrifuging with water alone, the oil contend can be reduced to 8-10%. The standard for disposal for alpha olefins in the Gulf of Mexico is around 6%. With the formulation described in part 4 we could reduce the oil content down to 4-5% levels if provided more than 2 days of contact between the solution and the cuttings (see empty square series in Figure 2). To decrease this contact time to a few minutes (it is important to avoid waste accumulation on drilling installations) we introduced octyl sulfobetaine, a zwiterionic surfactant that act as a lime soap-dispersing agent (LSDA). Using levels of 1% LSDA in the formulation we reduce the necessary contact time to 30 minutes (see empty circle series in Figure 2).

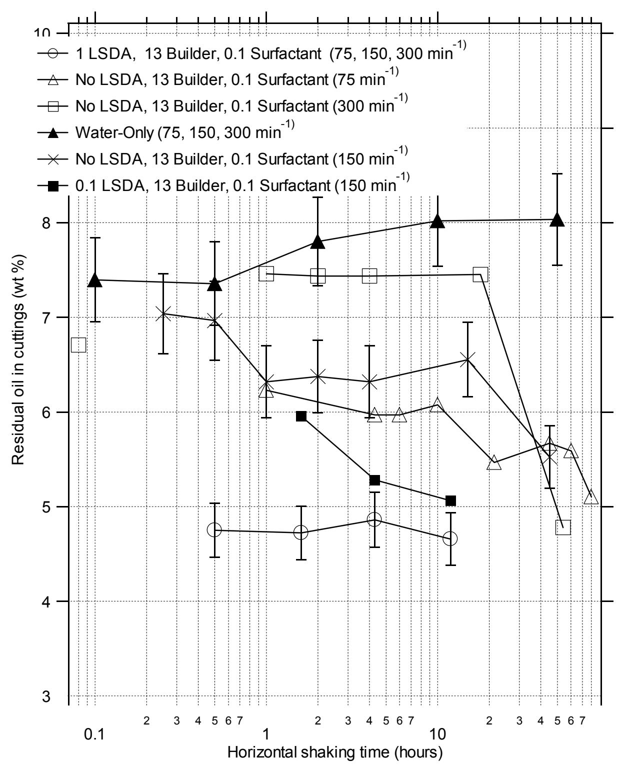

Figure 2. Studies on kinetics of oil removal from cuttings

Publications/ Presentations:

Childs J., Sabatini D. A., Acosta E., and Scamehorn J. F. *Surfactant Enhanced Treatment of Oil-Based Drill Cuttings and Oil-Contaminated Soils*. 7th Annual International Petroleum Environmental Conference. Houston, TX. November 8th, 2000.

Future activities:

1. – Study the production of fines during the washing process
2. – Study the importance of each additive: surfactant, builder, lime soap dispersant (octyl sulfobetaine) by performing washing studies with different combinations of this three additives.
3. – Perform a pilot field study (pending future funding) and analyze the economics of the process.

Supplemental Keywords: drill cuttings, alfa-olefins, surfactant, builder, zwiterionic, kinetics, interfacial tension, removal, risk

Relevant Web Sites:
http://ipec.utulsa.edu/Ipec/Projects.html