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SURTEK

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TECHNICAL PROGRESS REPORT

DOE Contract No DE-AC22-92 BC14886

Investigation of Oil Recovery Improvement by Coupling
an Interfacial Tension Agent and a Mobility Control Agent
in Light Oil Reservoirs

submitted by
Surtek, Inc.

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OSTI

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Report for the Period of
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I. Objectives of Study

The study will investigate two major areas concerning co-injecting an interfacial tension reduction agent(s) and a mobility control agent into petroleum reservoirs. The first will consist of defining the mechanisms of interaction of an alkaline agent, a surfactant, and a polymer on a fluid-fluid and a fluid-rock basis. The second is the improvement of the economics of the combined technology.

This report examines the effect of polymer addition to different combinations of alkaline agents and surfactants. Xanthan gum and polyacrylamide polymers were evaluated. In addition, the effect of alkali and polymer on the critical micelle concentration of different surfactant types was investigated.

II. Summary of Technical Progress

Critical Micelle Concentration of Surfactants Blended with Alkali - The addition of Na_2CO_3 , NaHCO_3 , NaOH , Na_2HPO_4 , and Na_3PO_4 to alpha olefin, linear side chain alkyl aryl sulfonate, branched side chain alpha olefin, and internal olefin sulfate surfactant solutions did not effect the critical micelle concentration. Addition of either polyacrylamide or xanthan gum polymers to the alkaline plus surfactant solutions did not alter the critical micelle concentration either. The critical micelle concentration was determined by measuring the conductivity, surface tension, and interfacial tension of alkaline-surfactant solutions in which the surfactant solution was increased at a constant alkali concentration.¹ The data are listed in the following table.

<u>Surfactant</u>	Critical Micelle Concentration (wt% active)					
	<u>Alkali</u>	<u>NaOH</u>	<u>Na_2CO_3</u>	<u>NaHCO_3</u>	<u>Na_3PO_4</u>	<u>Na_2HPO_4</u>
Bioterge AS-40	0.020	0.010	0.010	0.020	0.005	0.010
Bioterge AS-40 + 1000 mg/l Alcoflood 1135	0.040	0.010	0.010	0.015	0.010	0.020
Petrostep B-100	0.020	0.010	0.016	0.020	0.015	0.020
Petrostep B-100 1000 mg/l Alcoflood 1135	0.060	0.030	0.040	0.020	0.020	0.020
LXS 420	0.060	0.005	0.005	0.010	0.005	0.010
LXS 420 + 1000 mg/l Alcoflood 1135	0.020	0.020	0.010	0.020	0.010	0.020
IOS 1518	0.040	0.040	0.040	0.040	0.020	0.040
Petrostep B-105	0.010	0.010	0.010	0.010	0.010	0.010

Effect of Polymer on Interfacial Tension of Alkaline-Surfactant Solutions - The effect on the interfacial tension between the Adena crude oil and aqueous solutions of adding either polyacrylamide or xanthan gum polymers to an alkaline plus surfactant solution was evaluated. Cyantrol 750 was the polyacrylamide and Kelco X7D-226 was the xanthan gum. Na_2CO_3 , NaHCO_3 , NaOH , Na_3PO_4 , and Na_2HPO_4 were mixed with an alpha olefin (Bioterge AS-40), a linear alkyl aryl sulfonate (LXS 420), and a branched linear alkyl aryl sulfonate (Petrostep B-100). Spinning drop interfacial tension² and DuNouy ring³ measurements were performed at 72°F.

Figure 1 depicts data for Na_2CO_3 plus Petrostep B-100 with both polymers. Figure 1 data are typical of all the surfactant plus alkali combinations. Interfacial tension values increased with addition of either polyacrylamide or xanthan gum. The interfacial tension increase was observed with each of the alkaline agents, as shown in Table 1. The magnitude of the interfacial tension change was essentially identical whether with xanthan gum or with polyacrylamide.

As the surfactant concentration was increased to 0.5 wt%, the interfacial tension increase due to polymer addition was less than with 0.1 or 0.2 wt% surfactant. Increasing the polymer concentration, altered the interfacial tension further. Increases and decreases of the interfacial tension were observed. Again, no different was observed between the two polymer types.

The change of interfacial tension with polymer addition indicated surfactant and alkali interfacial reduction synergism is altered by the presence of polymer.

Continued Investigations - Continued investigations are to study the effect of salinity and cation content of the solution on the interfacial tension, viscosity, and critical micelle concentration of the alkaline plus surfactant and alkaline plus surfactant plus polymer solutions and the long term stability of the chemical solutions.

III. References/Publications

1. Author W. Adamson: Physical Chemistry of Surfaces, Wiley-Interscience, New York, Third Edition, page 477 (1976).
2. Cayias, J.L., Schechter, R.S. and Wade, W.H.: The Measurement of Low Interfacial Tension via the Spinning Drop Technique," Adsorption at Interfaces, ACE Symposium Series, No. 8, page 234-247 (1975).
3. ASTM D971

Effect of Polymer Addition on the
Interfacial Tension Between Aqueous Alkali and Surfactant
Dissolved in 1000 mg/l NaCL
and Light Crude Oil at 72°F

Polymer Concentration Cyanatrol 750 mg/l	Interfacial Tension (dynes/cm)* with				
	NaOH 1.25wt%	Na ₂ CO ₃ 2.0 wt%	NaHCO ₃ 2.0 wt%	Na ₃ PO ₄ 2.0 wt%	Na ₂ HPO ₄ 2.0 wt%
0.1 wt% Petrostep B-100					
0	0.001 s	<0.001 s	0.013 s	0.002 s	0.002 s
400	0.069 s	0.040 s	0.023 s	0.016 s	0.024 s
800	0.069 s	0.047 s	0.023 s	0.029 s	0.024 s
1200	0.069 s	0.047 s	0.023 s	0.035 s	0.020 s
0.2 wt% Petrostep B-100					
0	0.001 s	<0.001 s	0.010 s	0.024 s	0.008 s
400	0.045 s	0.040 s	0.019 s	0.016 s	0.020 s
800	0.045 s	0.047 s	0.023 s	0.024 s	0.024 s
1200	0.045 s	0.040 s	0.023 s	0.024 s	0.029 s
0.5 wt% Petrostep B-100					
0	0.078 s	0.010 s	0.016 s	0.008 s	0.016 s
400	0.045 s	0.020 s	0.019 s	0.016 s	0.020 s
800	0.045 s	0.040 s	0.019 s	0.024 s	0.020 s
1200	0.045 s	0.046 s	0.019 s	0.024 s	0.016 s

* Interfacial tension values denoted with
a "D" to the right are DuNouy ring
tensiometer determinations. Those with
an "s" are spinning drop measurements.
ppt = precipitate wg = wets glass

Interfacial Tension Between Aqueous Alkali + Surfactant + Polymer versus Polymer Concentration

Figure 1

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