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BEHAVIORS OF POLYMERS AND SURFACTANTS SOLUTIONS IN PRESENCE OF ELECTROLYTES

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Chemical methods for enhanced oil recovery have been studied for a long time. Chemical method rate expressed by the ratio efficiency/procedure price becomes favorable according to the recent progress of the alkali-surfactant-polymer combination method. The advantages of polymer flooding and micelle-polymer flooding are combined by this procedure.

The compatibility between polymer and surfactant solutions is the main parameter for the optimisation of this combination method. In order to obtain the sufficient viscosity and the low interfacial tension of these solutions, it is necessary to know the conditions under which the different additives are compatible. We have studied the monophase to diphase transition of the system, the critical salinity of the phase separation and the effect of temperature (1).

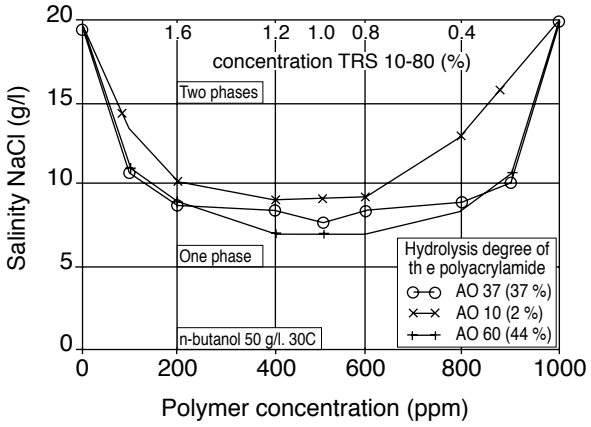


Figure 1

Phase behavior of TRS 10^{-} 80^{+} polyacrylamide solution (30°C, n-butanol 50 g/l).

1 PHASE BEHAVIOR OF THE SYSTEM

At fixed salinity, a solution of surfactant solution (TRS 10-80) at 2% active material with 5% of n-butanol is mixed with 1% polyacrylamide (AD 37)-n-butanol solution in different proportions. The solutions are stirred and rested at constant temperatures (30, 60, 80, 90°C) until the equilibrium is reached. Figure 1 represents the chemical stability domain at 30°C of TRS10-80/AD37 solutions as a function of the total salinity. In general, we observed either a monophasic solution or a separation in two liquid phases.The composition of each phase has been analyzed for several polymer-surfactant system choosen near the phase separation limit. The upper phase is rich in surfactant and n-butanol compared to the initial composition. The lower phase contains mainly thepolyacrylamide.

2 CRITICAL SALINITY OF PHASE SEPARATION

The determination of the critical salinity of phase separation was performed as a function of polymer or surfactant concentration and structure. Figure 2 indicates that the salinity where the phase separation occurs increases as

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the polymer or surfactant concentration decreases. This salinity value also depends on the polyacrylamide rate of hydrolysis.

Moreover, with the same experimental condition, the monophasic domain is enhanced at higher salinity when the n-butanol additive is changed by a more hydrosoluble additive like isobutanol. In the same way, the addition of 1% alkylpolyethoxy sulfonate (AES) to 1% TRS 10-80 solution with 2% n-butanol (ATN system) enhances the compatibility between polymer and surfactant by increasing the solubility of the products.

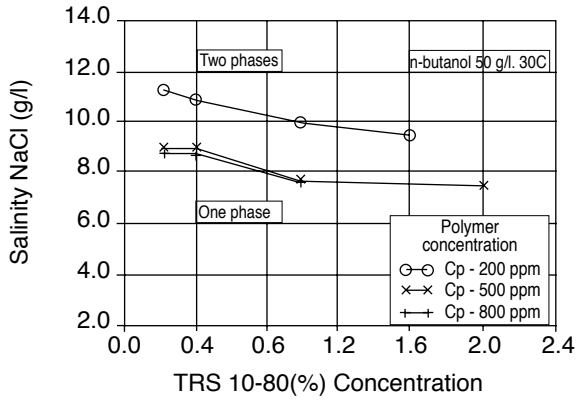


Figure 2

Variation of the critical salinity of TRS 10^{-} 80^{+} polyacrylamide solution vs. the surfactant concentration (30°C, n-butanol 50 g/l).

For the ATN system, we also observed that the critical salinity increases when the polymer is non-ionic like scleroglucan polysaccharide or when a terpolymer Hostamer is used (Table 1).

TABLE 1

ATN 1% + 0.5% polymer-30°C

polymer	AD37	Scleroglucan	Hostamer
critical salinity - NaCl g/l	19	30	57

3 RHEOLOGICAL BEHAVIOR

In the monophasic domain, the liquid phase has a classical behavior of pseudoplastic fluid. Polyacrylamide viscosity decreases with an increase of petroleum sulfonate concentration. Surfactants in polymer solution behave as a salt on the polyacrylamide molecule dimension and have no effect on scleroglucan conformation.

4 STABILITY AS A FUNCTION OF TEMPERATURE

Compatibility between polymer and surfactant increases with temperature. As shown in Figure 3, for the ATN system, NaCl critical salinity increases with temperature and varies with polymer structure. Over 60°C, surfactant concentration has an important effect on phase separation as the critical salinity decreases drastically. Phases analysis indicates that salts molecules are mainly in the polymer lower phase.

For thermal stability studies, the viscosity evolutions of different solutions over two months at 30, 60 and 90°C are presented in Figure 4. Stability as a function of time is strictly dependent on the polymer structure. The more degradable polymer, i.e polyacrylamide, the less stable the formulation. Hostamer —surfactant formulations has a better thermal behavior.

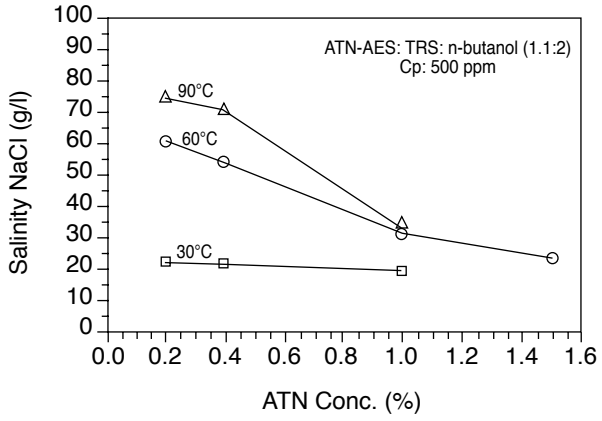


Figure 3

Variation of critical salinity of ATN + AD37 solution vs. ATN concentration (Cp = 500 mg/l, 30, 60, 80°C).

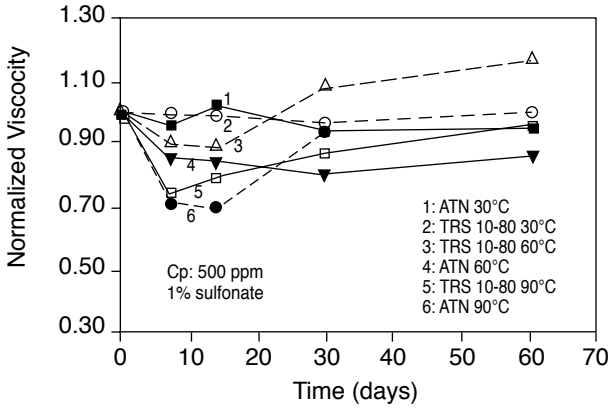


Figure 4

The thermal stability of Hostamer solution in the presence surfactants (30, 60, 90°C).

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