Effect of the Electrolyte Anion on the Salinity Contribution to Optimum Formulation of Anionic Surfactant Microemulsions

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The anionic surfactant-oil-water-alcohol systems exhibit a microemulsion - excess oil - excess water three-phase behavior when a so-called correlation for optimum formulation is fulfilled by the physicochemical variables. Up to now the contribution of the aqueous phase salinity to this correlation has been limited mostly to the sodium chloride effect. The correlation is extended to most sodium salts from monovalent to tetravalent and to their mixtures. A generalized equivalent salinity is proposed as $S_{Ne} = 2\ S_N / (1 + Z)$, where S_N is the sodium normality and Z the anion valence. The equivalent salinity is found to be independent of the sodium salt used. The term 2/(1+Z) is referred to as the "valence activity factor" (VAF); the VAF of a mixture is found to obey a linear mixing rule based on the mote fractions of the salts. © 1990 Academic Press, Inc.

INTRODUCTION

The effect of the physicochemical formulation on the phase behavior and interfacial tension of surfactant-oil-brine systems has been extensively studied in the past 15 years in relation to potential applications to enhanced oil recovery (1-4).

It is now well established that under certain circumstances, referred to as optimum formulation, the interfacial tension between the oil and the aqueous phases may reach an extremely low value (0.001 mN/m), such that the capillary forces essentially vanish.

At optimum formulation, the surfactant-oil-water systems exhibit several properties which are of utmost importance in enhanced oil recovery and other applications:

(1) Together with a deep minimum of the interfacial tension, the equilibrated system displays a high solubilization and very often a three-phase behavior (5, 6).

(2) Emulsified systems exhibit a minimum in viscosity (7) and a maximum in coalescence rate (8-12).

The combination of these properties has been shown to be the key to chemical flooding processes (13, 14), emulsified transport of heavy oils (15), and crude oil dehydration (16); it has also been used in emulsion polymerization processes (17).

OPTIMUM FORMULATION

As proposed by Winsor (18) 3 decades ago, an optimum formulation is characterized by an exact balance between the interactions of the oil and water phases. It was recently emphasized that the Winsor R ratio allows the qualitative interpretation of all observed phase transition phenomena (19). However, it fails to be useful on a quantitative basis since the interaction energies cannot be accurately calculated at the present.

Extensive experimental studies have shown that an optimum formulation is achieved whenever a certain empirical relationship is satisfied by the formulation variables. For anionic surfactant systems, the following expression was found to apply in many cases (20):

$$\ln S_0 - KACN - f(A) + \sigma + a_T(T-25) = 0 \qquad [1]$$

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