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Effects of Electrolytes on Zeta Potential and Stability of Triton X-100 and TRS 10-410 Stabilized Macroemulsion Systems

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The electrolytes are more effective in reducing charge on TRS 10-410 stabilized system as compared to Triton X-100 stabilized emulsion. The emulsion stability is influenced by flocculation, coalescence and creaming. Flocculation is significantly high at initial stage. As the concentration of electrolytes increases, the emulsions are more unstable resulting in decrease in the emulsion droplets. The rate of flocculation was determined by counting the droplets haemocytometrically and the zeta potential was evaluated from the electrophoretic mobility data.

Key Words: Surfactants, Macroemulsion, Flocculation, Zeta potential, Electrophoretic mobility.

INTRODUCTION

The present paper deals with the stability of macroemulsion of oil in water type stabilized by surfactants such as Triton X-100 (TX-100), a polyoxyether and TRS 10-410, a petroleum sulphonate and their stability in the environments of electrolytes.

Surfactants are amphipathic species that form a surface film at the interface between each colloid droplet and the dispersion medium, thereby lowering the interfacial tension, the term $\gamma_{IE}\Delta A$ of equation (1) and preventing coagulation.

$$\Delta G_{Emul} = \gamma_{IE}\Delta A - T\Delta S \quad (1)$$

The characteristics of surfactants to allow an interfacial tension gradient to exist and the tendency to achieve a low interfacial tension simultaneously, make surfactants an important reagent in chemical, pharmaceutical, mineral processing and petroleum engineering applications.[1–4]

EXPERIMENTAL

The surfactants TX-100 and TRS 10-410 were obtained from E. Merck and Witco Chemical Company and used as such without further purification. The hexadecane used as dispersed phase and the electrolytes used in experiments were of BDH (AnalaR grade). Double distilled water was used in all experiments.

Emulsion Preparation

The emulsions were prepared by mixing 5% volume of oil phase together with

1% emulsifier with aqueous phases containing 0.01 M sodium chloride to maintain ionic strength. The mixture was first hand shaken for half an hour and finally homogenized in a stainless steel homogenizer. The emulsion obtained was stable over a certain period of time. It was observed that the stability of an emulsion varied significantly with the order and rate of mixing emulsion components. Therefore, the emulsions were prepared under similar experimental conditions to get reproducible emulsions.

The electrophoretic mobilities of the emulsion droplets were measured macroelectrophoretically using a Northrop-Kunitz type flat rectangular cell. The electrokinetic potential was evaluated from the electrophoretic mobility data with the help of Helmholtz-Smouchowski equation:

$$\text{zeta potential} = 4\pi\eta U/D \quad (2)$$

where η is the viscosity, $\bar{U}$ is electrophoretic mobility and D is the dielectric constant of the medium. The viscosity and dielectric constant were assumed to be equivalent to the bulk phase, *i.e.*, water. These values were taken from the International Critical Table.

The rate of flocculation was determined by using German double Neubauer model haemocytometer. To count the numbers of associated and unassociated globules under Olympus microscope (15 × 100), a tally counter (Erma, Japan) was used. A duplicate counting was carried out with a fresh sample and the data reported here are an average value of the reading.

RESULTS AND DISCUSSION

The size distribution of emulsion droplets stabilized by TX-100 and TRS 10–410 are shown as histogram in Figs. 1 and 2 respectively. The range of size distribution for the two systems is from 0.55 to 1.35 M. However, an average diameter for TRS 10-410 stabilized emulsion is 1.05 μM and 0.95 μM for TX-100. For TRS 10-410 stabilized emulsion, majority of droplets are smaller than the average size, whereas for TX-100 stabilized emulsion, the droplets are almost

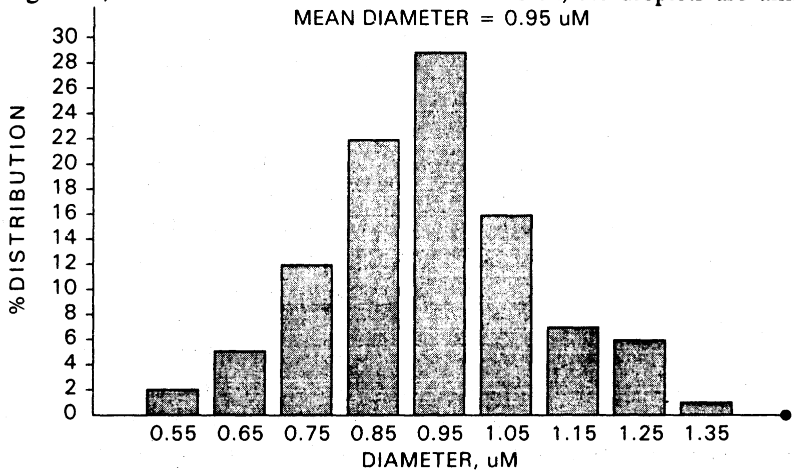

Fig. 1. Droplet size distribution of TX-100 stabilized emulsion

equally distributed from the average droplet size throughout the distribution range.

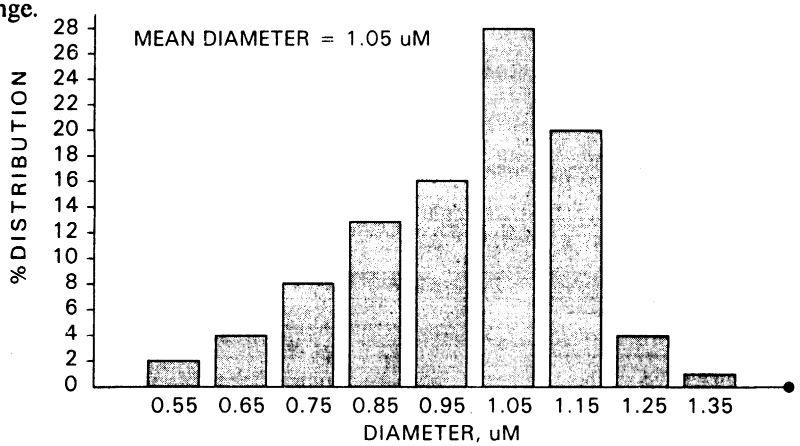

Fig. 2. Droplet size distribution of TRS 10-410 stabilized emulsion

The flocculation of the TRS 10–410 stabilized emulsion was studied, counting the change in droplet number as a function of time in presence of electrolyte, Fig. 3. A sharp decrease in the number of droplets was observed with elasped time, *e.g.*, about 50 min. This may be due to large decrease in the Debye length with the increase of ionic strength of the medium resulting in a fall in potential to its bulk value within a short distance. As a result, flocculation occurs due to van der Waals forces. The flocculation is significantly high at initial stage. As the concentration of NaCl increases the emulsions are becoming more unstable.

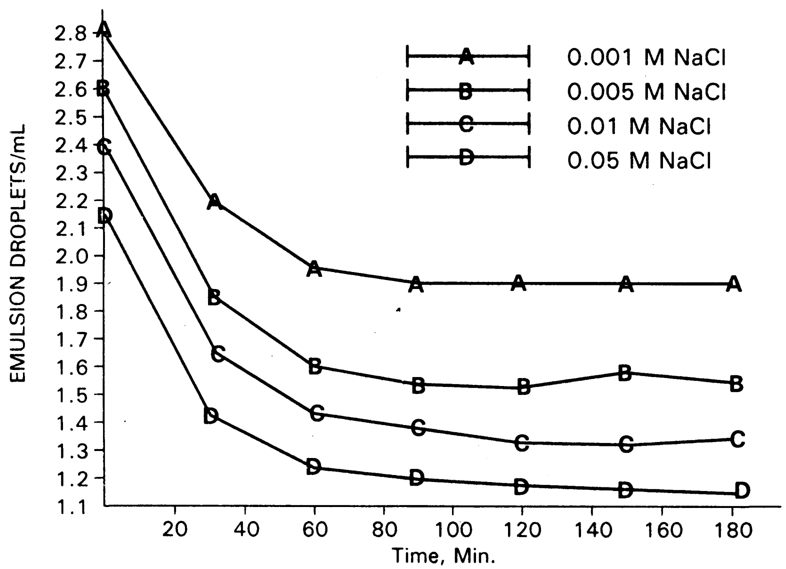

Fig. 3. Variation of number of droplets as a function of time for TRS 10-410 stabilized system in presence of NaCl

Figs. 4 and 5 illustrate the change in zeta potential as a function of electrolyte concentration for TX-100 and TRS 10-410 stabilized systems respectively. The

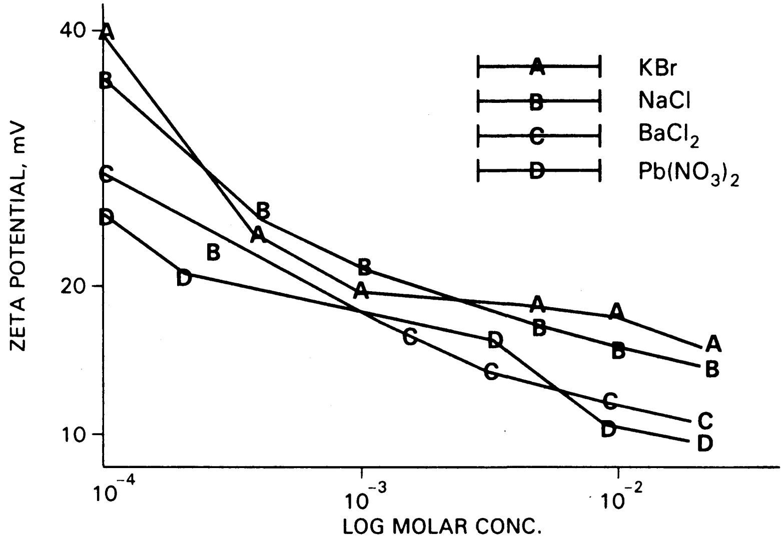

Fig. 4. Effect of electrolyte concentration on zeta potential on TX-100 stabilized system

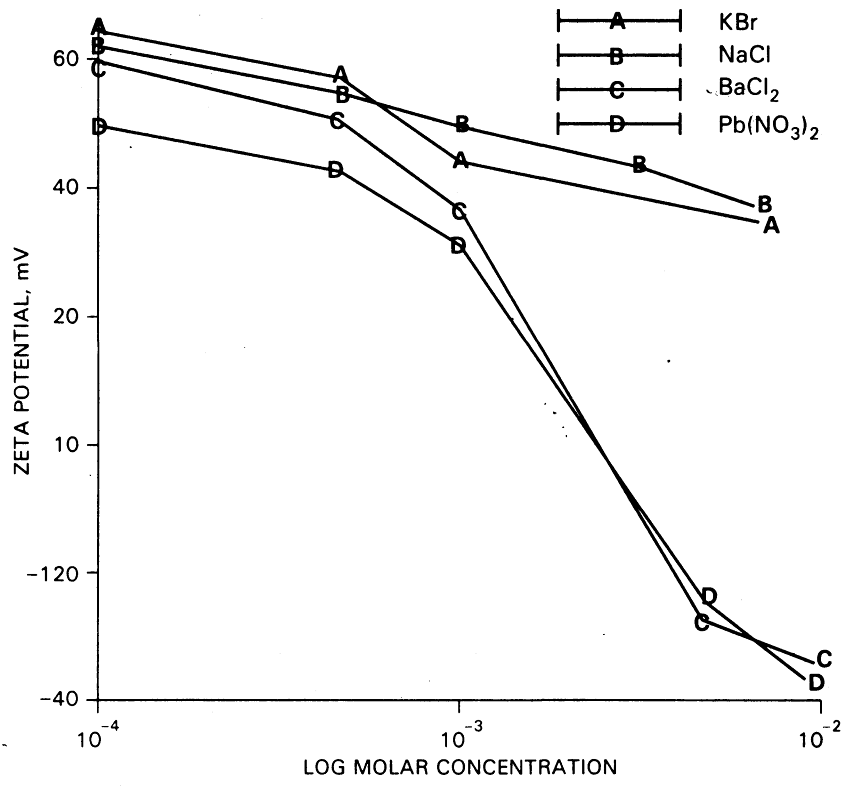

Fig. 5. Effect of electrolyte concentration on zeta potential on TRS 10-410 stabilized emulsion

divalent electrolytes are more effective in reducing charge as compared to monovalent electrolytes. The ionic group of TRS 10-410 is found to be more sensitive to the electrolytes as compared to nonionic TX-100 sytem. $BaCl_2$ and $PbNO_3$ form insoluble salts with TRS 10-410; this may further add to the instability of TRS 10-410 stabilized system. Therefore, electrolyte effect is more pronounced for TRS 10-410 system. The experimental data of zeta potential for TX-100 and TRS 10-410 stabilized systems are given in Tables 1 and 2 respectively.

TABLE-1
EFFECT OF ELECTROLYTES ON ZETA POTENTIAL OF TX-100 STABILIZED EMULSION

Electrolytes	Concentration (M)	Zeta potential (mV)
KBr	1.0×10^{-4}	38.63
	5.0×10^{-4}	26.85
	1.0×10^{-3}	22.45
	5.0×10^{-3}	21.78
	1.0×10^{-2}	20.63
	2.0×10^{-2}	18.19
NaCl	1.0×10^{-4}	36.08
	5.0×10^{-4}	27.53
	1.0×10^{-3}	25.32
	5.0×10^{-3}	20.83
	1.0×10^{-2}	19.25
	2.0×10^{-2}	17.38
$BaCl_2$	1.0×10^{-4}	30.38
	1.0×10^{-3}	18.58
	5.0×10^{-3}	16.73
	1.0×10^{-2}	13.89
	2.0×10^{-2}	12.65
$Pb(NO_3)_2$	1.0×10^{-4}	28.78
	1.0×10^{-3}	25.59
	5.0×10^{-3}	18.32
	1.0×10^{-2}	12.83
	2.0×10^{-2}	10.88

TABLE-2
EFFECT OF ELECTROLYTES ON ZETA POTENTIAL OF TRS 10-410 STABILIZED EMULSION

Electrolytes	Concentration (M)	Zeta Potential (mV)
KBr	1.0×10^{-4}	65.33
	5.0×10^{-4}	54.42
	1.0×10^{-3}	43.73
	5.0×10^{-3}	38.23
	1.0×10^{-2}	26.89
	5.0×10^{-2}	24.54
NaCl	1.0×10^{-4}	62.47
	5.0×10^{-4}	54.31
	1.0×10^{-3}	46.84
	5.0×10^{-3}	37.75
	1.0×10^{-2}	28.32
	5.0×10^{-2}	23.39
$BaCl_2$	1.0×10^{-4}	58.38
	5.0×10^{-4}	48.96
	1.0×10^{-3}	36.84
Charge reversal	5.0×10^{-3}	–28.35
	1.0×10^{-2}	–36.45
	5.0×10^{-2}	–46.82
$Pb(NO_3)_2$	1.0×10^{-4}	50.57
	5.0×10^{-4}	41.42
	1.0×10^{-3}	32.86
Charge reversal	5.0×10^{-3}	–26.96
	1.0×10^{-2}	–38.35
	5.0×10^{-2}	–46.42

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