EUFOAM, 3-6 July 2022, Krakow

FOAMABILITY OF PURE C_nTAB SOLUTIONS AND THEIR MIXTURE WITH N-OCTANOL

Agata Wiertel-Pochopien[1], Jan Zawala[1], Przemyslaw B. Kowalczuk[2]

[1] Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Science, Poland
[2] Norwegian University of Science and Technology, Department of Geoscience and Petroleum, Norway

Introduction

It is well known that mixtures of various collectors or collectors and frothers show often a synergetic effect, i.e. their overall effectiveness is greater than expected from their individual characteristics. This synergetic effect can affect significantly recovery and selectivity of a separation proces, and can also be related to foamability and foam stability. The paper presents a systematic investigation on the influence of mixtures of four cationic alkyltrimethylammonium bromides (C_nTAB, n=8, 12, 16, 18) and non-ionic n-octanol (C_8) surfactants on foamability.

Materials and methods

Commercially available **n-octanol** and alkyltrimethylammonium bromides (**C_nTAB**): octyltrimethylammonium bromide (**C_8TAB**), dodecyltrimethylammonium bromide (**C_{12}TAB**), cetyltrimethylammonium bromide (**C_{16}TAB**) and octadecyltrimethylammonium bromide (**C_{18}TAB**) were used as surface-active substances. Foamability and foam stability of pure C_nTAB solutions of various concentrations and their mixtures with n-octanol were performed using a **Dynamic Foam Analyzer** apparatus (DFA100, KRÜSS GmbH).

Foamability

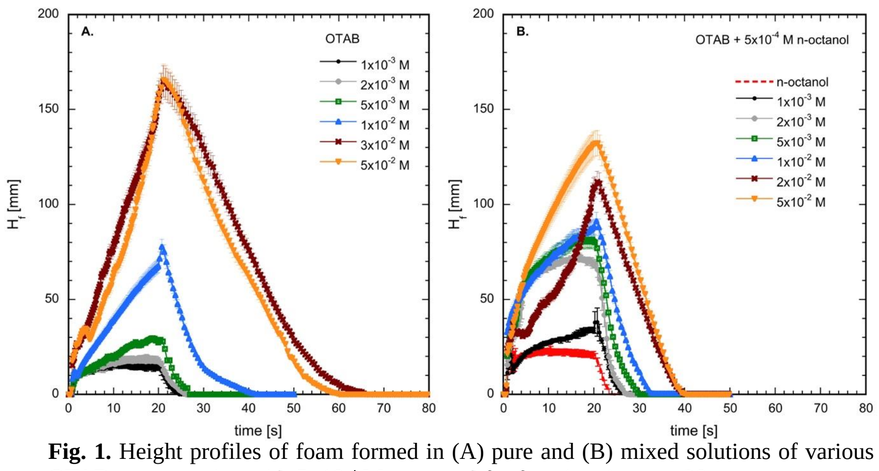

Fig. 1. Height profiles of foam formed in (A) pure and (B) mixed solutions of various OTAB concentration with 5×10^{-4} M n-octanol for foaming time t_f = 20 s.

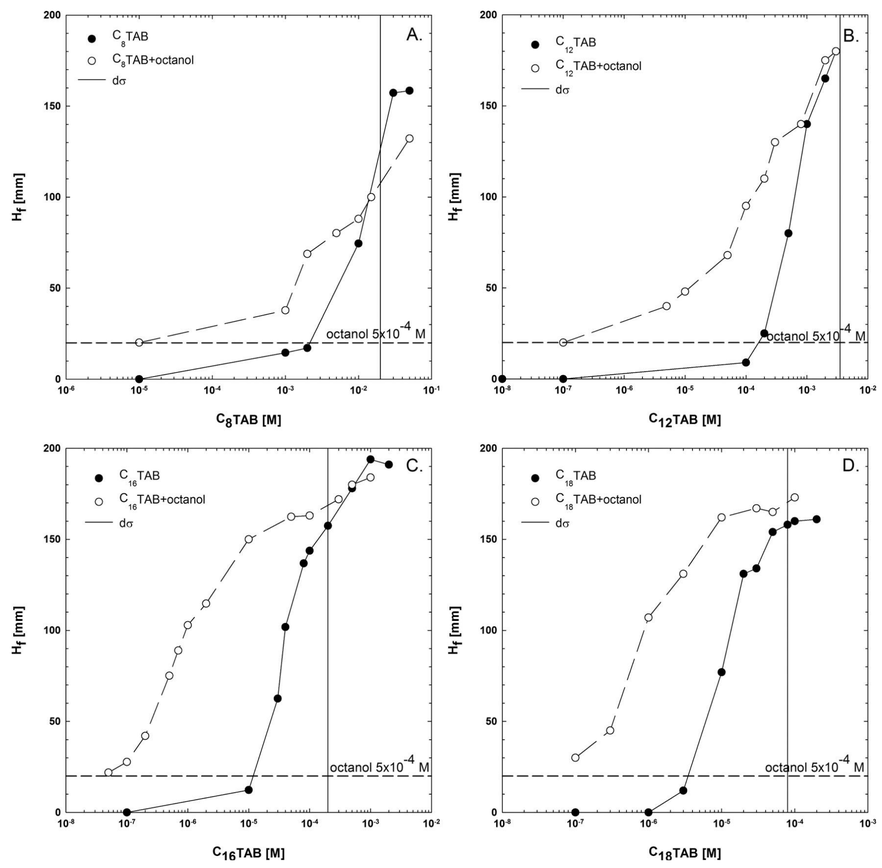

Fig. 2. Height of foam after foaming time equal to 20 s, for (A) C_8TAB, (B) C_{12}TAB, (C) C_{16}TAB and (D) C_{18}TAB solutions of various concentrations and its mixtures with various concentration of n-octanol.

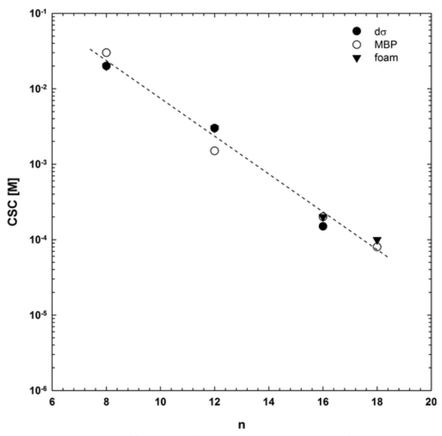

Fig. 3. Effect of the number of carbon atoms in the alkyl chain (n) of C_nTAB on the critical synergistic concentration (CSC) determined from the maximum bubble pressure (Figure 7), foamability (eq 1 and Figure 2).

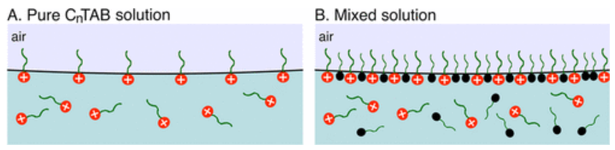

Fig. 4. Schematic illustration of the synergistic effect origin in the two-phase system−adsorption layer at the liquid/gas interface in (A) pure C_nTAB solution and (B) mixed solution of C_nTAB and n-octanol. Due to n-octanol presence, the adsorption coverage of CnTAB molecules can be much higher compared to that expected from its equilibrium value in the one-component solution.

Critical synergistic concentration (CSC)

Critical synergistic concentration (CSC) - characteristic concentration of C_nTAB above which the synergistic effect was either no longer visible or significantly reduced. CSC is determined from the equation 1:

$$d\sigma = \sigma_{water} - \sigma_{(c)} \quad \text{(eq 1)}$$

where σ_{water} and $\sigma_{(c)}$ are the equilibrium surface tensions of water and surfactant solution of a given concentration

To analyze the mechanism of the experimentally observed synergistic effect and determine accurately its concentration regimes, the data on dynamic surface tension, σ(t), were used.

To visualize directly the synergism existence, the following analysis protocol was proposed. Taking the dynamic surface tension data (Maximum Bubble Pressure method), the values of $d\sigma_{exp}(t)$ were calculated according to equation 1. Then, hypothetical $d\sigma_{sum}(t)$ values were calculated as:

$$d\sigma_{sum}(t) = d\sigma_{C_nTAB}(t) + d\sigma_{octanol}(t) \quad \text{(eq 2)}$$

where:

$$d\sigma_{C_nTAB}(t) = \sigma_{H_2O} - \sigma_{C_nTAB}(t) \quad \text{(eq 3)}$$
$$d\sigma_{octanol}(t) = \sigma_{H_2O} - \sigma_{octanol}(t) \quad \text{(eq 4)}$$

To check whether the synergistic effect really exists and to assess its magnitude, the linear regression in the form:

$$d\sigma(t) = a \cdot \ln(t) - b \quad \text{(eq 5)}$$

was fitted to the dσ(t) ($d\sigma_{exp}(t)$ and $d\sigma_{sum}(t)$) data, and the slope coefficient, *a*, was calculated.

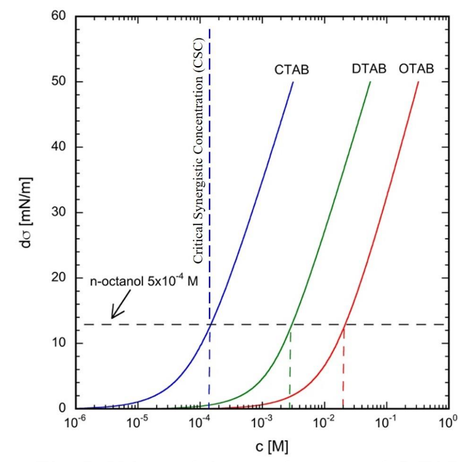

Fig. 5. Values of dσ as a function of C_nTAB solution concentration. Way of determination of the CSC values on the basis of d*σ* value.

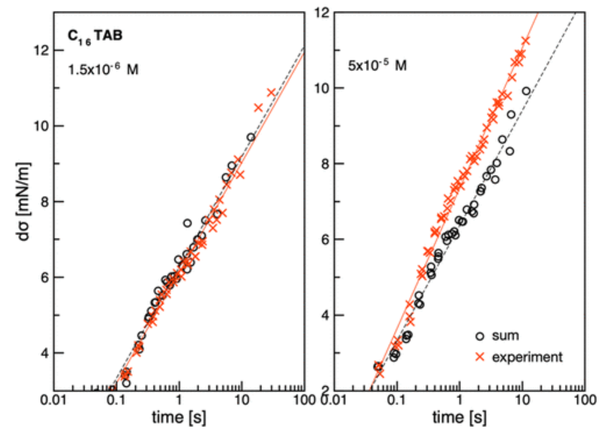

Fig. 6. Values of $d\sigma_{exp}(t)$ and $d\sigma_{sum}(t)$ (calculated according to eqs 1−5) as a function of time with fitted linear regression lines for determination of their linear slopes (parameters *a*) for two chosen C_{16}TAB concentrations. The *a* parameters were used for assessment of the degree of surface tension decrease in mixed C_nTAB solutions.

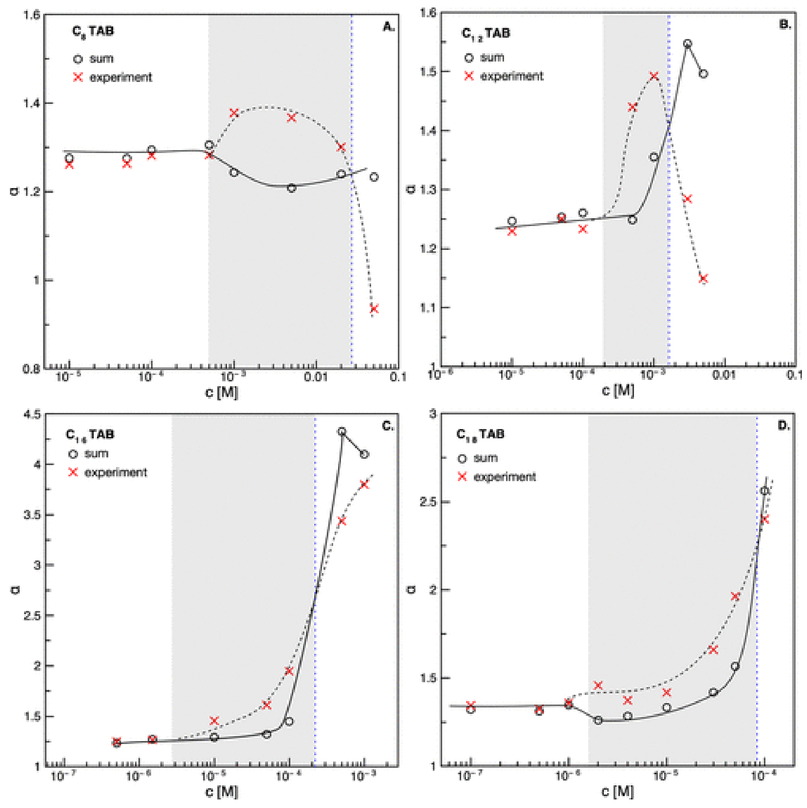

Fig. 7. Linear slopes (parameters a_{sum} and a_{exp}) determined for all mixed solutions of studied C_nTAB with 5×10^{-4} M n-octanol, according to the protocol presented in Figure 6.
(A): n = 8, (B) n = 12, (C) n = 16, (D) n = 18. Solid and dashed lines added to guide the eye.

Conclusions

- Synergism occurred for the mixed systems, which resulted in the increased foam height compared to the performance of one-component solutions.
- A synergistic effect between investigated surfactants exists only, if the adsorption coverage of C_nTAB molecules was lower than corresponding coverage for n-octanol.
- The strongest effect was observed for C_{16}TAB, and it was significantly reduced with the carbon chain length decrease.
- The addition of n-octanol to the C_nTAB solution resulted in an increase of the C_nTAB molecule surface concentration (Γ) at the liquid/gas interface (see Figure 4B).