Bubble surface mobility regimes in aqueous solutions of simple organic solvents

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Studies of bubble behavior in mixed surfactant solutions attract rising interest due to growing industrial applications. In this work, we study the mobility of a bubble surface in two types of aqueous solutions. The first type consisted of aqueous solutions of organic solvents, namely ethanol [1], propanol [1], acetone, acetic acid, and acetonitrile. All these compounds form hydrogen bonds with water, and their arrangement at the molecular level is characterized by the formation of clusters. The second type consisted of aqueous solutions of short-chain alcohols (ethanol, propanol) mixed with a stronger fluorinated surfactant with lower surface tension, which allowed observation of changes in surface tension [2]. The terminal velocity of bubbles (Db ≤ 1 mm) in a stationary liquid was measured in the above-mentioned solutions, and the normalized velocity and normalized drag coefficient were calculated from known theoretical limits. This made it possible to determine the mobility of the bubble surface. The surface of bubbles rising in highly diluted solutions of organic solvents with and without surfactant additives is immobile or partially immobile. With increasing concentrations of both types of additives, the mobility of the bubble surface changes. In aqueous solutions of organic solvents, bubble surface remobilization occurs at concentrations that correspond to the formation of clusters at the molecular level. In alcohol solutions with fluorosurfactant, as the alcohol concentration increases, alcohol molecules replace the surfactant in the surface layer. Fitting the surface tension data for the mixture using co-surfactant model shows that such replacement can be due to strong interaction between alcohol and surfactant resulting in a considerable decrease in surfactant activity. As a consequence, at propanol molar fraction 0.3 and ethanol molar fraction 0.5, surfactant adsorption is completely hindered while alcohol dominates the adsorption layer. The gradients of surface tension are diminished resulting in remobilization of the bubble surface, which manifests itself in an increase in terminal bubble rising velocity. The study revealed that surface remobilization in mixed solutions occurs at higher alcohol concentrations than in surfactant-free solutions.

Keywords:
Bubble surface remobilization, bubble velocity, surface tension, organic solvents, fluorosurfactant

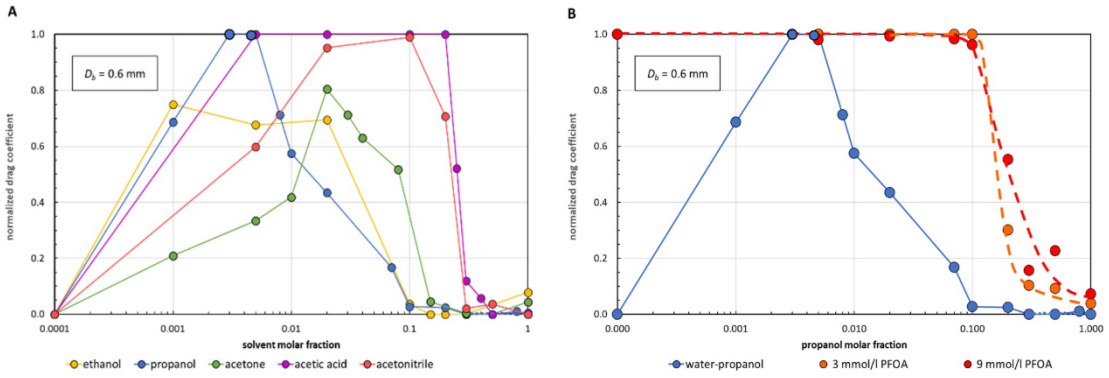

Fig. Dependence of normalized drag coefficient on mixture composition (CDnorm = 1 pro mobile bubble surface, CDnorm = 0 for immobile bubble surface). A. Organic solvents C2–C3. B. Water – propanol mixture with perfluorooctanoic acid (PFOA). Bubble diameter 0.6 mm.

References:

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