Effect of Oily Additives on the Foamability and Foam Stability. 1. Role of Interfacial Properties

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ABSTRACT

Foam tests and model experiments with sodium dodecyl-benzene-sulfonate solutions are performed to clarify how the foam stability and the foaminess are affected by several oils of different chemical structure. The foam tests show that 2-butyloctanol (2BO, branched alkanol) and isohexyl-neopentanoate (IHNP, branched ester) exhibit a significant antifoam activity at concentrations as low as 0.005 wt %. n-Heptanol also acts as an antifoam, but at concentrations above 0.15 wt % due to its higher solubility in the surfactant solution. The model experiments prove that the antifoam activity of pre-emulsified oils is determined primarily by the barrier to drop entry, which controls the drop emergence on the solution surface. If the entry barrier is high (e.g., n-dodecanol and silicone oil), the oil drops remain arrested in the Plateau borders during the process of foam drainage, without being able to destroy the foam. Thus branched long-chain alkanols (like 2BO) and esters (IHNP) behave as active antifoams, because they combine the advantages of long-chain and medium-chain n-alkanols -- low solubility and low entry barrier, respectively. No direct correlation between the spreading behavior of the oils and their foam breaking activity is observed. The effect of these oils on the foamability of the solutions is far more complex. At low concentrations (below and around their solubility limit) the oils reduce the dynamic surface tension of the solutions, facilitating in this way the formation of fresh surface and enhancing the foamability. At higher oil concentrations, however, the emulsified oil drops induce a coalescence of the foam bubbles during foaming and, as a result, the foamability of the solutions decreases. That is why the foamability is a non-monotonic function of the oil concentration.

Keywords: foam stability, foamability, antifoam, surface elasticity, oil spreading

Effect of Oily Additives on the Foamability and Foam Stability. 2. Entry Barriers

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ABSTRACT

In the preceding paper of this series we studied the effect of several oils of different chemical structure on the foaming properties of sodium dodecyl-benzene-sulfonate (SDDBS) solutions. A straightforward correlation was found between the foam stability and the so called "entry barrier", which prevents the emergence of pre-emulsified oil drops on the solution surface. In the present article we perform a systematic experimental study of the entry barriers for several oils by means of the recently developed Film Trapping Technique. The latter consists in trapping oil drops in wetting films on a solid substrate, followed by a controlled increase of the capillary pressure of the meniscus that compresses the drops against the substrate. At a certain critical capillary pressure, P_C^{CR}, the asymmetric oil-water-air films rupture and the drops enter the water-air interface. This event is observed microscopically and P_C^{CR} is determined as a function of various parameters (type of oil, surfactant concentration, drop size, and others). The entry barrier increases with the surfactant concentration, especially in the range where the surfactant micelles are expected to stabilize the asymmetric films. The results obtained with a series of alkanes (from octane to hexadecane) show that the entry barrier increases with the alkane chain-length. Furthermore, it is shown that the presence of a spread oil (even as an ultra-thin, molecular layer) on the surface of the foam film might lead to a significant change of the magnitude of the entry barrier. For decane and dodecane, the layer of spread oil reduces the entry barrier, whereas for hexadecane the effect is the opposite. As far as we know, such a role of oil spreading in the antifoaming action of oils has not been reported so far. Since the stability of thin liquid films is usually discussed in the literature in terms of the disjoining pressure, we estimate from the experimental data the critical disjoining pressure, Π_{AS}^{CR}, at which the asymmetric oil-water-air film ruptures and the drop entry occurs. The estimates show that the curvature of the asymmetric film is very important in the overall consideration of the mechanical equilibrium in the system and there is a big difference between the numerical values of P_C^{CR} and Π_{AS}^{CR}, unlike the case of planar films where $P_C^{CR} = \Pi_{AS}^{CR}$. Additionally, we find that P_C^{CR} is a weak function of the oil drop size and of the asymmetric film radius, while Π_{AS}^{CR} scales as (film radius)$^{-1}$ for all of the studied systems. These results are discussed with respect to the possible mechanisms of film rupture. Concerning the foam stability, P_C^{CR} is a more convenient quantity for description of the entry barriers, because its magnitude correlates with the foam height, whereas the magnitude of Π_{AS}^{CR} does not.

Keywords: foam stability, antifoam, entry barrier, film trapping technique, disjoining pressure.

Antifoaming Action of Oils

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Abstract

Antifoams are widely used for control of the foam stability in various products (detergents, paints, pharmaceuticals, and many others). A significant progress in the understanding of the foam destruction mechanisms by oil-containing antifoams has been achieved recently. Experiments with antifoams comprising silicone oil and hydrophobic silica showed that the antifoam entities (emulsified globules or lenses floating on the solution surface) easily form unstable oil bridges between the two surfaces of the foam film. These bridges rapidly stretch in radial direction, due to uncompensated capillary pressures at the oil-water and oil-air interfaces, and eventually rupture the foam films. As a result, the foam is destroyed within several seconds by the mixed solid-liquid antifoams. In contrast, drops of silicone oil deprived of silica are unable to enter the foam film surface due to significant entry barriers. In these systems, the oil drops are expelled into the neighbouring Plateau borders (PBs), and the foam collapse is observed at a much later stage of the foam evolution, when the drops are compressed by the walls of the narrowing PBs (defoaming time on the order of minutes and hours). The magnitude of the entry barriers can be quantified by the so called Film Trapping Technique (FTT).