Effect of Foam Height on the Structure of Foams Stabilized by Branched-Chain Sugar-Based Surfactants

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Branched-chain sugar-based surfactants exhibit unique aggregation behavior and interfacial properties because of their bulky hydrophobic chains. Our previous studies demonstrated that the branched-chain surfactant *b*C_{15}Mal exhibits lower foaming ability than the corresponding linear-chain surfactant C_{12}Mal, while small-angle X-ray scattering (SAXS) measurements revealed the formation of thin liquid films with thicknesses of several tens of nanometers in the foam. However, the internal structure of the foam films and its spatial variation within a foam column have not yet been clarified. Since gravitational drainage continuously changes the liquid fraction after foam formation, the foam structure is expected to vary depending on the foam height. In this study, small-angle neutron scattering (SANS) measurements were performed to investigate the height-dependent structure of foams stabilized by *b*C_{15}Mal.

Foams were continuously generated by bubbling air through aqueous *b*C_{15}Mal solutions in a quartz cell, and SANS profiles were collected at different heights of the foam column using the SANS-U instrument at JRR-3. The scattering profiles obtained at different foam heights were compared to evaluate structural variations associated with liquid drainage. Optical microscopy was also performed to observe the evolution of bubble morphology, while previous SAXS, dynamic surface tension, and interfacial viscoelasticity measurements were used to support the interpretation of the SANS results.

The SANS profiles showed systematic changes depending on the position within the foam column. These differences are considered to reflect variations in the local liquid fraction and the structure of the foam films caused by gravitational drainage. In particular, the upper region of the foam is expected to contain thinner liquid films because of the lower liquid content, whereas relatively thicker liquid films remain in the lower region. Such structural differences are also consistent with the changes in bubble morphology observed by optical microscopy during foam aging.

Compared with X-rays, neutrons provide higher sensitivity to light elements and enable structural characterization of aqueous soft-matter systems with excellent penetration through thick foam samples. Therefore, SANS is particularly suitable for investigating the internal structure of foams without significantly disturbing the foam structure. The height-dependent SANS profiles obtained in this study provide valuable information on the structural inhomogeneity of foams that cannot be obtained from macroscopic foam height measurements alone.

Quantitative model analysis of the SANS profiles is currently in progress to determine the characteristic structural parameters of the foam films at different heights. Correlation of the SANS results with foam stability and previous SAXS measurements is expected to clarify how drainage affects the microscopic structure of foam films stabilized by branched-chain sugar-based surfactants. These findings will contribute to a better understanding of the stabilization mechanism of foams and provide useful guidelines for the design of highly stable foaming systems.

Future quantitative analysis using appropriate structural models will enable a more detailed characterization of the foam films and the local aggregate structure at different foam heights. This information is expected to provide a microscopic understanding of how gravitational drainage influences foam stability, demonstrating the usefulness of SANS for investigating heterogeneous foam systems.