Observation of Bubble Oscillation Induced by Bubble Breaking with Acoustic Method

Junqi Ding[1*], Felicia Tsaur[1], Alex Lips[1], and Adnan Akay[2]

1. Unilever Research & Development, Trumbull, CT 06611, * junqi.ding@unilever.com
2. Department of Mechanical Engineering, Carnegie Mellon University, Pittsburgh, PA 15213-3890

Bubble collapse is a particularly important subject which has been attracting scientific attentions for more than decades[1]. The noise and material damage can be caused by the high velocities, pressure and temperature that may result from the collapse. To analyze the noise generated from the collapsing bubbles may reveal the important information of the mechanism of bubble collapsing and energy transferring[2,3].

Foams with different size distributions and mode radius were generated by two steps. First, the large size bubble system was produced by shaking the sodium dodecyl sulfate (SDS) or sodium laureth sulfate (SLES) solution (at a little bit above their critical micellar concentrations (CMCs), respectively) in a fixed volume, closed container. The foams with large distributed size bubbles were then broken down to smaller bubbles with the target size distribution by applying different stirring speeds for a certain time. The resulted foams were put in a Petri dish where two microphones were located nearby. The noise from the foams was recorded and analyzed by home-made software with very strong FFT power.

The frequency spectrum of foam noise strongly depends on the mode radius of bubbles. For the systems with larger mode radius bubbles, the acoustic frequency sits from 4k to 8kHz. The distribution of the power spectrum density forms a board peak in this range. If the mode radius of foam becomes smaller and smaller, there are two peaks in the power spectrum density graph. The peak between 4k to 8 kHz remains almost intact while the second peak shifts to higher frequency ranges as the mode radius goes down. The second peak fits pretty well with the bubble oscillation model based on the known size distribution. The first peak in the frequency spectrum is believed from the contribution of bubble breaking. The acoustic signal can be contributed from two sources: the bubble breaking and the oscillation from the nearby bubble excited by the collapsed bubble. The movies captured by super-fast camera confirmed that the bubbles next to the breaking bubble oscillating under the influence of the wave generated by the bubble breaking.

Reference:

1. Brennen CE: *Cavitation and bubble dynamics*, vol 44. New York: Oxford University Press Inc.; 1995.
2. Vandewalle N, Lentz JF, Dorbolo S, Brisbois F: **Avalanches of popping bubbles in collapsing foams**. *Physical Review Letters* 2001, **86**:179-182.
3. Lohse D: **Bubble puzzles**. *Physics Today* 2003, **56**:36-41.

Keywords: foam collapse, acoustic, surfactant, bubble oscillation, bubble breaking