Bouncing bubbles shake up emulsion studies

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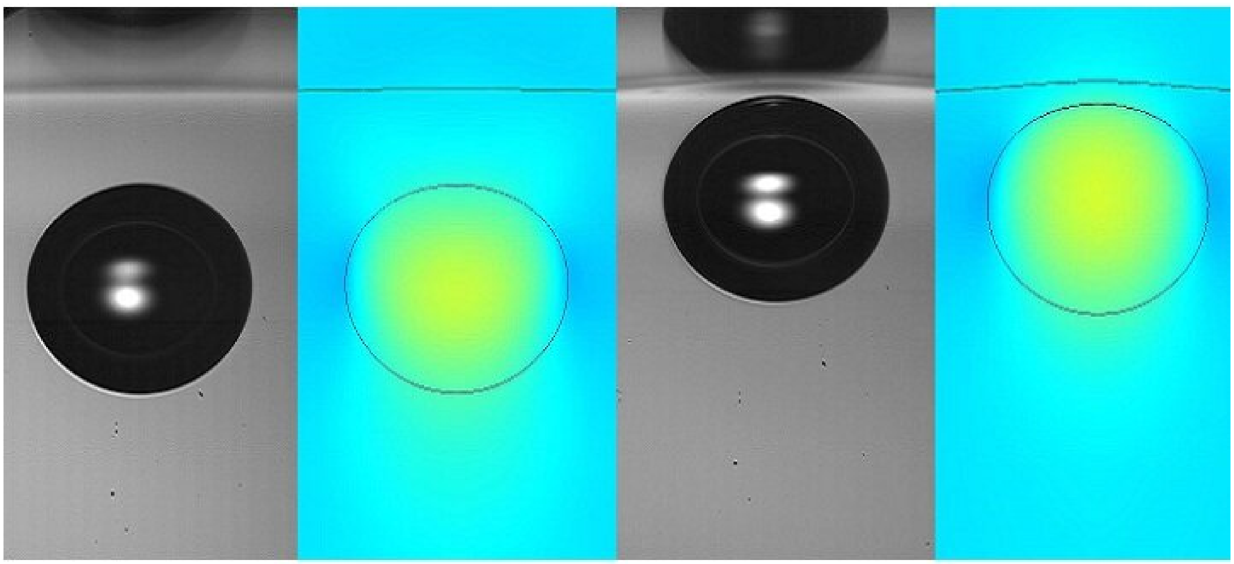

High-speed camera snapshots and simulations of bubbles bouncing from water-air interfaces can be used to detect trace amounts of contaminants. Credit: Ivan Vakarelski

Some of the fastest video cameras ever developed have been used by KAUST researchers to clarify how molecular-scale changes to water surfaces may impact the performance of industrial-scale purifications.

One factor that influences the stability of emulsions is how quickly small bubbles or droplets join together into larger droplets. Ivan Vakarelski, a research scientist in Sigurdur Thoroddsen's lab, notes that this type of coalescence is driven by variables ranging from bubble size, collision speed, and the "freedom" of molecules located at liquid surfaces.

"When liquids contact a solid, they tend to stick due to strong molecular forces. In contrast, a clean liquid exposed to air can move along relatively easily—we call that a mobile interface," explains Vakarelski. "It's a fundamental property that determines the behavior of many foams and emulsions."

Recently, Thoroddsen and his team used their expertise at high-speed imaging to observe collisions between air bubbles formed in a perfluorocarbon, a liquid with similar viscosity to water that can be refined to an ultrapure state. To their surprise, these bubbles did not coalesce as fast as anticipated. Instead, the high mobility of the air-perfluorocarbon interface caused the bubbles to repeatedly bounce off each other before merging.

In their latest work, the KAUST researchers broadened their investigations to the world's most important liquid—water. A clean air-water interface is supposed to be mobile, however, numerous studies suggest they have low molecular freedom because they are highly susceptible to contamination.

To resolve this quandary, Vakarelski helped design an experiment that used thin films of fatty acids to completely immobilize a free water surface. Then, they released millimeter-sized air bubbles that floated to the interface and crashed into it. When images of the rebounding bubbles were compared to ones taken on purified water surfaces, the team saw that the fatty acid film drastically reduced the degree of bouncing.

"A common belief is that once water is exposed to the atmosphere in a laboratory, it's impossible to keep it clean enough to be mobile," says

Vakarelski. "However, our study shows that this is not correct—a standard purification device produces an interface that bounces bubbles back quite strongly."

Successful tests of this approach with other liquids, such as ethanol, indicate that bubble analysis could help solve problems in food processing applications as well as chemical production.

More information: Ivan U. Vakarelski et al. Free-Rising Bubbles Bounce More Strongly from Mobile than from Immobile Water–Air Interfaces, *Langmuir* (2020). DOI: 10.1021/acs.langmuir.0c00668

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