Mystery of texture of Guinness beer: Inclination angle of a pint glass is key to solution

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Bubble texture of Guinness beer in a pint glass, featuring the creamy taste of tiny bubbles and fascinating texture motion. Credit: Osaka University

A team of researchers from Osaka University and Kirin Holdings Company, Limited demonstrated that the texture formation in a pint

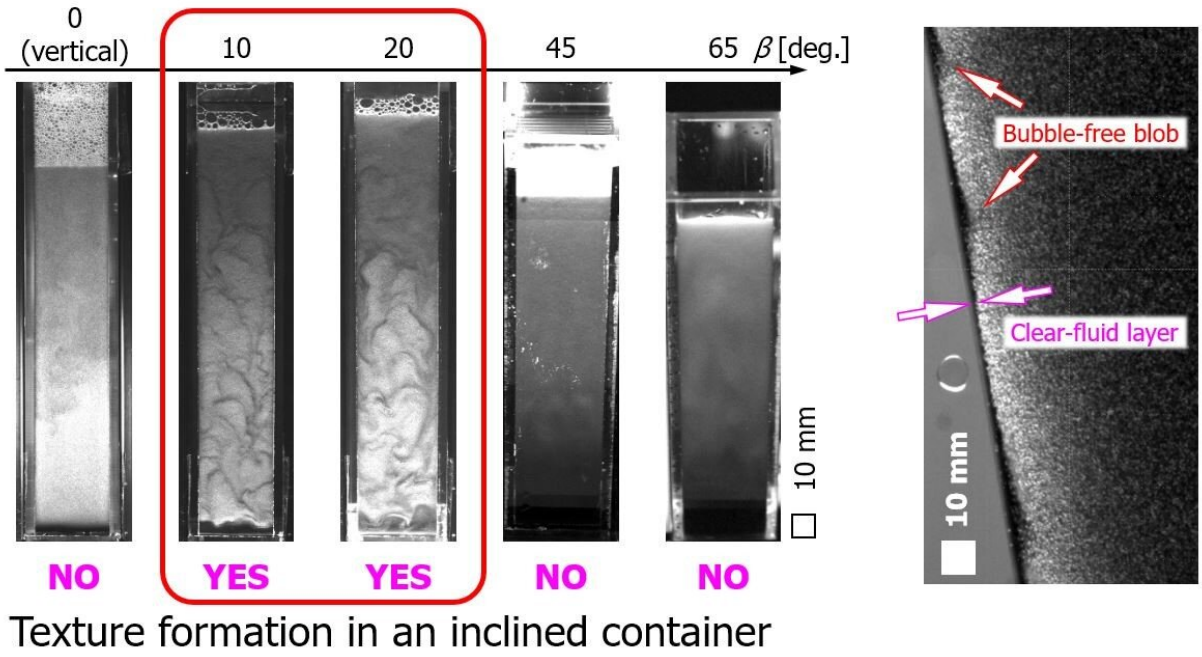
glass of Guinness beer is induced by flow of a bubble-free fluid film flowing down along the wall of the glass, a world first. This phenomenon is found to be analogous to roll waves commonly observed in water sliding downhill on a rainy day. Their research results were published in *Scientific Reports*.

Guinness beer, a dark stout beer, is pressurized with nitrogen gas. When it is poured into a pint glass, small-diameter bubbles (only 1/10 the size of those in carbonated drinks such as soda and carbonated water) disperse throughout the entire glass and the texture motion of the bubble swarm moves downward.

Although some models have been proposed to explain how the downward wave of a bubble swarm forms in Guinness beer, the mechanism underlying the texture formation was an open problem.

Because the opaque and dark-colored Guinness beer obstructs physical observation in a glass, and computation using supercomputers is necessary to conduct numerical simulation of flows including a vast number of small bubbles in the beer, the team of researchers led by Tomoaki Watamura produced transparent "pseudo-Guinness fluid" by using light particles and tap water. They filmed the movement of liquid with a high-speed video camera, using laser-induced-fluorescence in order to accurately measure the movement of fluid. In addition, using molecular tags, they visualized the irregular movement of the fluid.

With these methods, the team poured pseudo-Guinness fluid in an inclined container to observe how the texture formed. The texture formation appeared only in the region of about 1 mm away from the inclined wall, and didn't appear in the vertical wall vicinity.



Bubble texture in a rectangular container for various inclination angle β (left): Side view of bubble-texture formation in the inclined wall vicinity (right), showing the clear-fluid layer (bubble-free film) and the spatial thickness fluctuations (bubble-free fluid blobs) along the inclined wall. Credit: Osaka University

They also observed a clear-fluid (bubble-free) film flow down along the inclined wall in the inclined wall vicinity, capturing velocity and thickness of bubble-free film flowing downward. While the texture appeared when the glass inclination angles were small, it did not when they were large, demonstrating that the texture formation in a glass of Guinness beer was caused by the roll-wave instability of the gravity current.

Lead author Watamura says, "There are a large number of small objects in nature, such as fine rock particles transported from rivers to the sea

and microorganisms living in lakes and ponds. Comprehending and regulating the movement of small objects is important in various industrial processes as well. Our research results will be useful in understanding and controlling flows of bubbles and particles used in industrial processes as well as protein crystallization and cell cultivation used in the field of life science."

More information: Tomoaki Watamura et al, Bubble cascade in Guinness beer is caused by gravity current instability, *Scientific Reports* (2019). DOI: 10.1038/s41598-019-42094-0

Provided by Osaka University