The spreading of hydrosoluble surfactants on water

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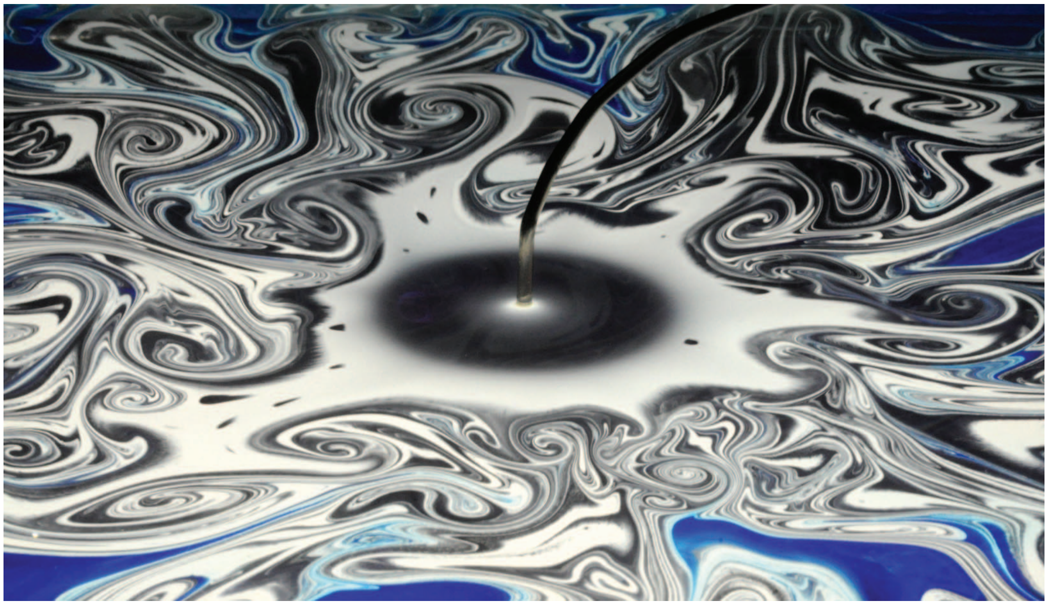

FIG. 1. A side view from above the air-water interface of the Marangoni flow induced by the continuous injection of an aqueous solution of surfactants (SDS) on the surface of a layer of ultra-pure water containing blue ink.

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Heterogeneities in the distribution of surfactants at an interface between two fluids create a gradient of interfacial tension, which triggers the Marangoni effect, i.e., a bulk flow in the two phases surrounding the interface.[1] The Marangoni effect is used to enhance the spreading of liquids on substrates,[2] and some living organisms rely on this to move at the surface of water.[3] It can also impair processes such as surface coating.[4]

Most of the studies in the past have focused on the spreading of water-insoluble amphiphiles on water. However, the study of the spreading of an aqueous solution of hydrosoluble surfactants on a layer of water reveals a wealth of beautiful patterns and fascinating questions that combine hydrodynamics and physicochemistry.

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Figure 1 shows a typical occurrence of a Marangoni flow induced by the spreading of a solution of hydrosoluble surfactants (sodium dodecyl sulfate (SDS), Sigma-Aldrich, $[SDS] = 260$ mM) continuously injected at the surface of a layer of ultra-pure water. The flow is visualized by injecting passive tracers (olive oil droplets, $d \simeq 10\ \mu$m) that are seeded in the surfactant solution. These tracers scatter light and appear as white on the picture. Contrast at the interface is enhanced by dying the water layer with a blue ink.

The interface is divided in three flow regions: a source, itself surrounded by a zone where little tracer signal can be seen. Outside this latter region, 2D mushroom-like structures grow, reminiscent of hydrodynamic instabilities such as the Rayleigh–Taylor mechanism. The transparent zone is characterized by fluid velocities that are one to two orders of magnitude greater than the velocities anywhere else on the interface.

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