Scaling up the acoustic removal of bubbles from viscoplastic fluids

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The behaviour of bubbles in viscoplastic fluids is central in processing of thermoplastics, lubrication, and in the food and cosmetic industry. Bubbles can be beneficial, for instance when they are used to impart texture to a food product, or they can be detrimental as they can negatively affect the thermal conductivity or optical transparency of a material.

Viscoplastic fluids exhibit a threshold in applied stress (yield stress) below which the material behaves like an elastic solid, and above which it flows like a liquid. Bubbles are therefore harder to remove from a viscoplastic fluid than from a simple viscous fluid: in the regime where the material behaves like a solid, the bubbles are indefinitely trapped, as you can see for instance in hand sanitizer and hair gel. In a chemical processing flow, undesired gas bubbles can be entrapped in the fluid.

There is experimental evidence that bubbles can be removed from viscoplastic fluids by ultrasonication. A better understanding of the behavior of bubble dynamics in viscoplastic fluids under ultrasonication is key to controlling this phenomenon, and to optimizing processes and products. In our group we have performed microscale experiments to observe the behavior of individual bubbles in response to ultrasound excitation. We have highlighted different fundamental phenomena of bubble dynamics that come into play in the process.

In this project you will scale up this process to bench scale with the goal to remove trapped air bubbles from optically transparent, model viscoplastic fluids, for instance concentrated surfactant solutions, polymer solutions, and polymer gels. You will develop robust sample preparation protocols to carefully control the effects of ageing and thixotropy of these fluids. You will image the evolution of the bubble population using high-resolution camera recordings and you will process the images using image analysis routines. The ultimate goal is to optimize ultrasound frequency, power and exposure time, to maximise bubble removal while minimizing the acoustic energy input.

Background reading: