Controlling Droplet Size Distribution in Emulsions

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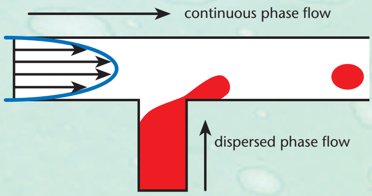
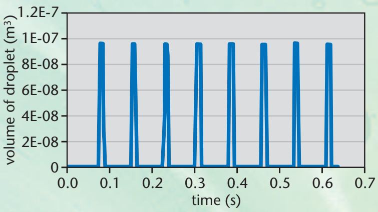
Emulsions are an important class of materials produced and handled by the chemical, food, pharmaceutical, and cosmetic industries. They consist of two immiscible liquids, one dispersed in the other. The properties of an emulsion are based on the droplet size distribution (DSD) of the dispersed phase. Because they are often thermodynamically metastable, there is a persistent threat that the texture of the emulsion will be altered during the course of preparation or packaging, or during the subsequent shelf life. Many processes over widely varying length scales could cause the DSD to change, and it is important that they be well understood so that the emulsion quality can be maintained.



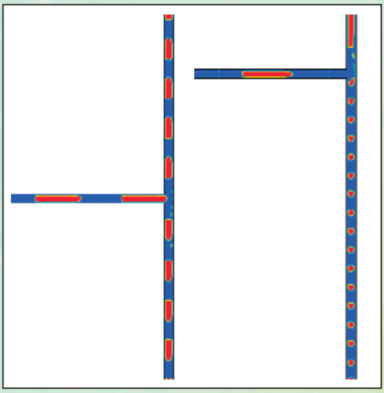
Schematic of the experimental setup [1]

For an ongoing project at Fluent, several aspects of droplet behavior have been studied using the volume of fluid (VOF) model. Some of the results have been compared to experiments that were carried out on microfluidic devices, where a precise droplet size distribution could be generated. For example, the generation of droplets at a T-junction using two streams of immiscible liquids has been simulated. Droplets of uniform size were rapidly and reproducibly produced at the junction as a result of the surface tension and the shearing motion of the fluid in the main channel, in agreement with measurements.



Volume of droplets produced at the T as a function of time

In another study, the geometrically mediated breakup of droplets in a microfluidic device [2] was simulated. By changing the length of the arms of the T-junctions, the droplet can be split into daughter droplets of unequal size. By using a network of asymmetric T-junctions, emulsions of a given DSD can be produced. Both 2D and 3D simulations matched the qualitative and quantitative aspects of the experiments, such as the size of the daughter droplets for a given T-junction and the critical parameters required for droplet breakup as a function of capillary number. ■



Droplet breakup at a symmetric (left) and an asymmetric (right) T-junction

References

1 Nisisako, T., Torri, T. and Higuchi, T.: Lab Chip. Vol 2, no 1. pp 24-26, 2002.

2 Link, D.R., Anna, S.L., Weitz, D.A. and Stone, H.A.: Phy. Rev. Lett. Vol. 92, pp 1178-1180, 2004.