

Droplet generation assisted by axial vibrations: a sensitivity study

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Membrane emulsification (ME) consists in forcing a dispersed phase through a porous membrane, directly generating droplets into a continuous flowing phase. Whereas the impact of longitudinal vibrations on emulsification is well documented, the effect of transversal vibrations (*i.e.* perpendicular to the membrane surface) has been less discussed. Arnaud and Dominique coupled ME with transversal vibrations and found that smaller droplets were produced with a narrower size distribution [1]. In order to understand the effect of transversal vibrations on emulsification, we focus on a simplified configuration where a single droplet is generated in a stagnant surrounding liquid. The aim of this work is to reproduce qualitatively Arnaud and Dominique's results, to understand the droplet generation mechanisms and to investigate how the operating and physicochemical parameters may affect the detachment mode and the droplet final size.

A single-pore vibrating setup has been designed to observe droplet formation and detachment. It consists in a capillary tube of submillimeter-sized inside diameter fed with the dispersed phase (dodecane). The capillary tube is fixed onto a vibration exciter and emerges in a transparent tank filled with the continuous phase (distilled water). A high-speed camera captures droplet breakup and image analysis is performed providing data such as droplet size and elongation. We studied the effect of various parameters including the frequency and amplitude of vibration, the dispersed phase flow rate, the pore diameter, the surface tension (adjusted by the addition of SDS) and the dispersed phase viscosity (adjusted by the addition of paraffin).

At fixed forcing frequency, significantly smaller droplets (up to 76% lower in diameter) are generated once a threshold amplitude is reached. A droplet grows and resonates in first mode when it reaches a critical size proportional to $f^{-1/2}$. During resonance, if the droplet attains a critical elongation ratio of about 7/3, it detaches prematurely by an end-pinching mechanism. Otherwise, it continues to grow and detaches at larger sizes in dripping mode. The different parameters tested affect the threshold amplitude and droplet final size. For example, lower threshold amplitudes are obtained for lower surface tensions, larger pore diameters or lower dispersed phase viscosities. Dispersed phase flow rates do not affect threshold amplitudes significantly. Smaller droplets are obtained for smaller pore diameters, lower surface tensions, lower dispersed phase flow rates or higher frequencies. Dispersed phase viscosity does not significantly affect droplet diameters. These results are consistent with the model proposed for droplet detachment.

LITERATURE:

[1] C. Arnaud, N. Dominique, brevet n° 02 12803, 15th october 2002.