

## **Mechanisms of droplet breakup during high-amplitude forced oscillations: understanding membrane emulsification coupled with transversal vibrations**

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Membrane emulsification consists in forcing a dispersed phase through a porous membrane, directly generating droplets into a continuous phase. Arnaud and Dominique showed that by coupling membrane emulsification with transversal vibrations, smaller droplets were produced, with a narrower size distribution [1]. These are key criteria for industrial applications. The aim of this work is to understand the droplet breakup mechanisms induced by the vibrations.

Thus, a single-pore vibrating setup has been designed in order to observe droplet detachment. It consists in a capillary tube (of submillimeter-sized inside diameter) fed with the dispersed phase (dodecane) by a syringe pump. The capillary tube is fixed onto a vibration exciter and emerges in a transparent tank filled with the continuous phase (distilled water). The vibration exciter delivers sinusoidal vibrations with frequencies tested ranging from 0Hz to 200Hz and amplitudes swept between 0mm and 1mm. Droplet detachment was captured with a high-speed camera and image analysis was performed providing data such as droplet elongation ratio and droplet final size. We studied the effect of the frequency and amplitude of vibration on the droplet final size as well as the impact of the dispersed phase flow rate, the pore diameter and the surface tension (adjusted by the addition of SDS).

At fixed forcing frequency, it appears that the variations of the drop diameter as a function of the vibration amplitude exhibit a strong discontinuity, with a decrease in the droplet diameter of up to 76%. The amplitude threshold at the discontinuity is inversely proportional to the forcing frequency and depends on the pore diameter and on the surface tension. Furthermore, at the amplitude threshold, the droplet size is inversely proportional to the square root of the forcing frequency.

We associate the discontinuity with the transition between two modes of droplet detachment: dripping and stretching. Dripping occurs below the amplitude threshold: the droplet grows until the buoyancy force roughly balances the capillary force. Above the amplitude threshold, stretching takes place: the droplet grows until its first mode eigenfrequency coincides with the forcing frequency. Then, the droplet oscillates, stretches at resonance and finally detaches. This mechanism only occurs above the amplitude threshold because the vibration amplitude is large enough for the droplet to reach a critical elongation ratio for breakup.

### **LITERATURE:**

[1] C. Arnaud, N. Dominique, Dispositif et procédé de fabrication d'un mélange, d'une dispersion ou émulsion d'au moins deux fluides réputés non miscibles, patent n° 02 12803, 15<sup>th</sup> october 2002.