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1 Introduction

• Experimental study of droplet formation in a microfluidic cross-junction, the simplest geometry.
• Two configurations: with and without surfactant.
• Two steps identified during squeezing: filling and pinching.
• Different production regimes are observed as Capillary number (Ca) and flow rate ratio ($\phi$) are varied in a large range.

2 Parameters

Fixed: H, W, $\eta$, $\mu_C$, $\sigma$

Varied: $Q_D$, $Q_C$

$W^* = \frac{W}{H}$
$\eta = \frac{BD}{H}$
$\frac{Ca}{WH} = \frac{Q_D}{Q_C}$

$\phi = \frac{Q_D}{Q_C}$

Dimensionless

Output: $L_d$, $F_d$ (droplet frequency)

$\Omega = \frac{Q_D}{E\sigma W^2 H}$

3 Phase diagrams

without surf., $W^* = 1.8$
with surf., $W^* = 3.2$

• periodical squeezing
• aperiodical squeezing
• dripping
• Secondary droplets

4 Satellite droplets

Satellite droplet looping in the vertical plane between two main droplets.
Satellite droplet looping in the horizontal plane between two main droplets.

Spatio-temporal diagram

5 Time decomposition

Two steps during squeezing:
Filling ($T_1$) and pinching ($T_2$).

$\Omega = \frac{Q_D}{E\sigma W^2 H} = \frac{1}{(T_1 + T_2)Q_D} \frac{1}{W^2 H}$

$\Omega = \Omega_1 + \Omega_2 \phi$

Position of the front interface during the formation of 10 successive droplets.

6 $\Omega_1$, $\Omega_2$

$\Omega_1$ & $\Omega_2$ vs. Ca (resp. $\phi$) with fixed $\phi$ (resp. Ca).
Solid line = fit on the whole dataset.
Dashed line = model of Chen et al. [1].
• without surf. • with surf.

7 Prediction of $\Omega$

Order of magnitude of time

$\Omega$ vs. empirical $\Omega^*$

8 Conclusion

• Model valid for large range of Ca & $\phi$ (extended range compared to previous models - limits of Chen’s model)
• Influence of surfactant mainly on $T_1$
• Aspect ratio $W^*$ determined thanks to satellite droplets.

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References