

## Enhanced and suppressed breakup of drops in confined geometries

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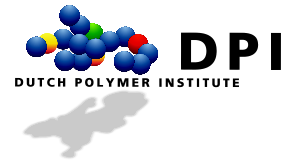
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# Enhanced and suppressed breakup of drops in confined geometries

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## Introduction

The Grace curve is a set of experimental data that describes the relationship between the viscosity ratio  $\lambda$  (of drop to matrix viscosity) and the capillary number  $Ca$  (ratio of viscous forces and interfacial forces) at breakup [1]. Recent experiments suggest that the behavior is different in confined geometries (Fig 1.), depending on the viscosity ratio [2]:

- $Ca_{crit}$  goes up for low-viscosity drops with increasing confinement ratio  $R/W$ .
- Equi-viscous drops are hardly affected.
- $Ca_{crit}$  goes down for high-viscosity drops.

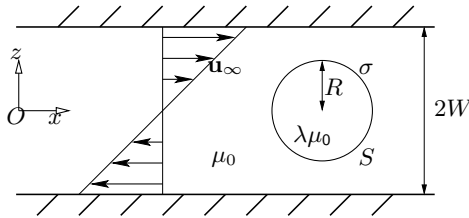


Fig. 1 Schematic picture of the problem.

## Objective

Investigate and explain the breakup behavior of confined drops.

## Methods

A boundary-integral method is used for the numerical simulations [3]. The experimental and numerical method are complementary to each other, as the simulations have difficulty with low-viscosity drops, while high-viscosity drops give complications in the experiments.

## Results

The critical capillary number for a large number of viscosity and confinement ratios is found in both experiments, as well as using our numerical method (Fig. 2).

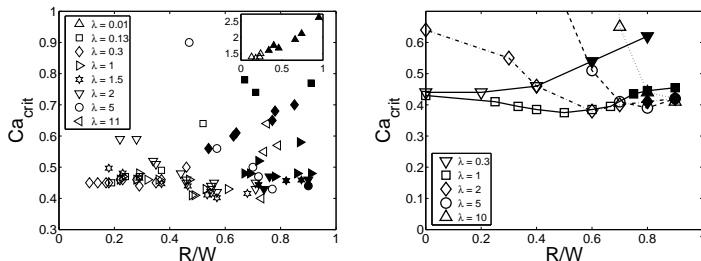


Fig. 2  $Ca_{crit}$  as function of the confinement ratio  $R/W$  for a large number of viscosity ratios  $\lambda$ . Experimental data left, and numerical results right.

Both methods show enhanced and suppressed breakup, depending on the viscosity and confinement ratio, and ternary breakup at high confinement ratios (Fig. 3, right).

## Breakup mechanism

To explain the behavior, we look at the influence of the walls on the rotation of the drop, and define several regions:

- I Unconfined behavior
- II The walls hinder rotation:  $Ca_{crit}$  goes down
- III Balance between II and IV
- IV Drops become long and align more in flow direction:  $Ca_{crit}$  goes up; onset of ternary breakup.
- V Asymptotic regime reached [4]

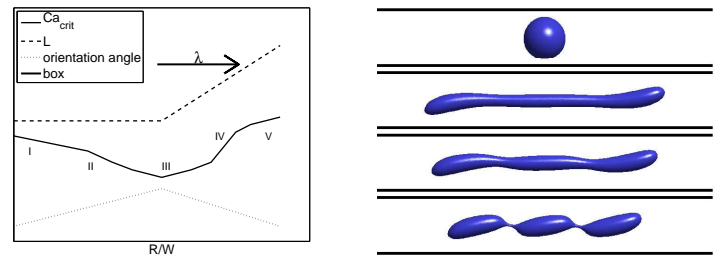


Fig. 3 Left: effect of the confinement on breakup. Right: ternary breakup.

Data to support this assumption is given in the next figure, where drop length and orientation angle in stable situations just below  $Ca_{crit}$  are given. The shift over the confinement axis is obvious.

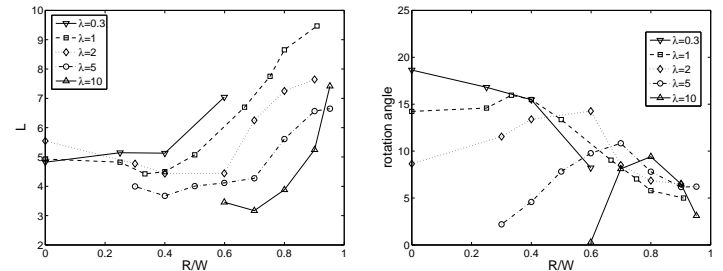


Fig. 4 Drop length and orientation angle for sub-critical  $Ca$ .

## Conclusions

The effect of confinement on drop breakup is investigated. Enhanced and suppressed breakup are explained by different alignment in flow direction. All viscosity ratios show the same behavior, but are shifted over the confinement axis, yielding *seemingly* different behavior for high and low viscosity ratios.

## References:

- [1] H.P. GRACE, CHEM. ENG. COMMUN., 14:225, 1982
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