

## Confined flow of polymer blends

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# Confined flow of polymer blends

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## Introduction

The trend toward miniaturization leads to processes in which the characteristic sizes of device and morphology are comparable. The goal is to study the influence of a confinement on the steady state morphology of two emulsions, differing in mutual miscibility and interfacial tension (Table 1).

## Materials and Methods

| $\frac{M_n^d}{M_n^m}$ | $(\frac{M_w}{M_n})_d / (\frac{M_w}{M_n})_m$ | $\eta_d / \eta_m (p)$ | $\sigma_{steady}$ |
|-----------------------|---|-----------------------|-------------------|
|                       |   | $[Pa * s]$            | $[mN/m]$          |
| PBD8K/PDMS60K         | 1.6/1.8                                     | 44.5/10.8             | 4.2               |
| PB635/PDMS60K         | 2.1/1.8                                     | 3.75/10.8             | 2.2               |

Table 1. Selected model components.

Three weight concentrations (10%, 20%, 30%) are investigated. Samples were sheared between parallel plates (gap spacing  $H=40 \mu m$ ) in a range of shear rates at which the transition from "bulk" behavior towards "confined" behavior was observed. Results are compared to the Maffettone-Minale model (MM model), as a function of the capillary number  $Ca$ , for bulk flows to detect deviations from bulk behavior.

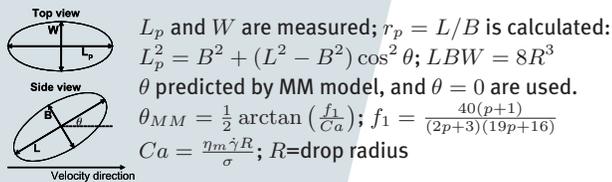


Figure 1. Deformed droplet in simple shear flow.

## Results

Drop deformations ( $r_p$ ) are fairly well predicted by the MM model for high enough shear rates. At lower shear rates (i.e. higher degree of confinements,  $2R/H$ ), better agreement is found by considering  $\theta = 0$  (Figure 2 and 3,  $r_p$  vs  $Ca$  curves).

## The immiscible PBD/PDMS system

For degree of confinement larger than 0.3, deviations of measured width  $W$  from the MM predictions are found for all the three concentrations (Figure 2).

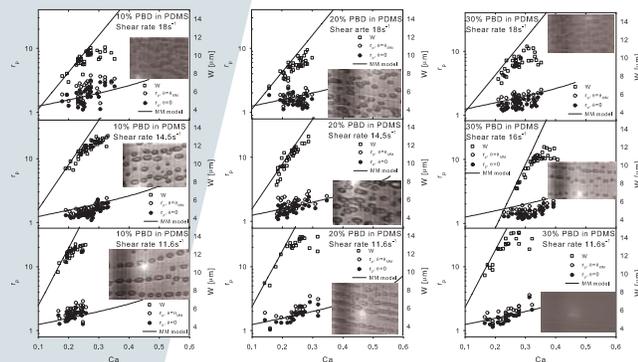


Figure 2. PBD/PDMS system: drop deformation  $r_p$  and drop width  $W$  as a function of the capillary number  $Ca$ .

## The partially miscible PB/PDMS system

For the PB/PDMS system,  $W$  vs  $Ca$  becomes constant at concentrations higher than 10% and for a larger degree of confinement.

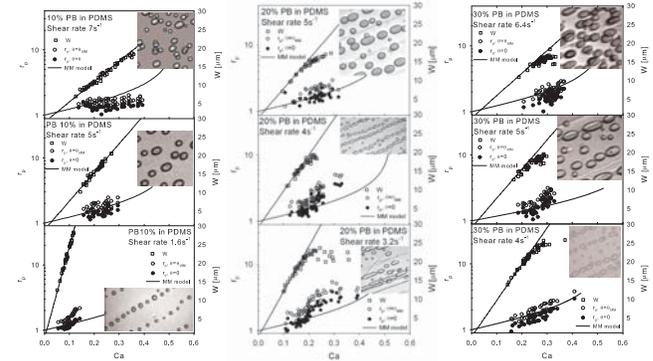


Figure 3. PB/PDMS system: as Figure 2.

## Morphology: strings

The dependence of the length  $L$  and the width  $B$  of the drops on  $Ca$  was investigated for the 20 wt% systems by fitting the experimental data with  $L \propto Ca^a$ ,  $B \propto Ca^b$ . The strong dependence of  $L/B$  on  $Ca$  is unique feature of strings in confined emulsions (Figure 4).

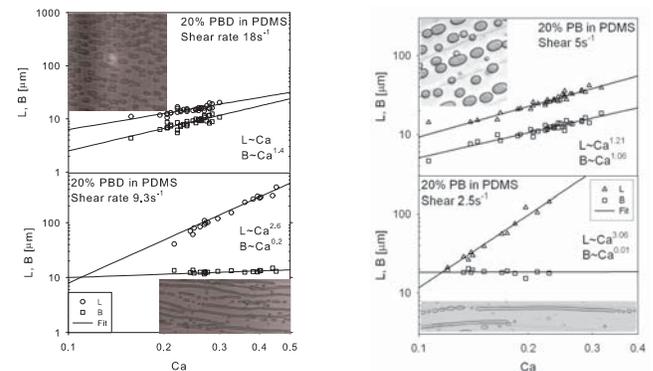


Figure 4. Dependence of the two sizes of droplets (top) and strings (bottom) on the capillary number. Experimental data for  $L$  (circles) and  $B$  (squares), and the results of fitting (solid lines) are shown. The inserts show the steady morphologies.

## Conclusions

By decreasing the shear rate, for each blend the same morphology evolution is encountered:

- ♦ droplets arrange into two layers, move to a single layer at a critical degree of confinement lower than 0.5 and finally superstructures, like ordered pearl necklaces and strings, form.
- ♦ The MM model does not fully predict the morphology evolution in the confined geometries.
- ♦ An unique condition to identify strings is proposed.