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

<table>
<thead>
<tr>
<th></th>
<th>$M^n/\sigma$</th>
<th>$\eta_d/\eta_m$</th>
<th>$\sigma_{steady}$</th>
</tr>
</thead>
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<tr>
<td>PBD8K/PDMS60K</td>
<td>1.6/1.8</td>
<td>44.5/10.8</td>
<td>4.2</td>
</tr>
<tr>
<td>PB635/PDMS60K</td>
<td>2.1/1.8</td>
<td>3.75/10.8</td>
<td>2.2</td>
</tr>
</tbody>
</table>

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.

Lp and W are measured; $r_p = L/B$ is calculated:

$L_p^2 = B^2 + (L^2 - B^2) \cos^2 \theta; LBW = 8R^3$;

$\theta$ predicted by MM model, and $\theta = 0$ are used.

$\theta_{MM} = \frac{1}{2} \arctan \left( \frac{f_1}{f_2} \right); f_1 = \frac{40(p+3)}{2(2p+3)(19p+16)}$.

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.