Miniaturization is a trend but how does it affect the break-up and coalescence of droplets in shear flow?

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For many years, polymer blending has been recognized as a method to generate materials with improved properties. These properties are highly dependent on the flow-induced phase morphology. The bulk dynamics of immiscible blends during flow is relatively well understood, especially when the system contains Newtonian components. Stimulated by the trend towards miniaturization, studies have recently focused on flow of immiscible blends in confined geometries. In that case the morphology development is not only affected by the material characteristics and the flow type, but also by the degree of confinement.

Here we present an overview on the morphology development in dilute, immiscible two-phase blends in confined shear flow. Droplet break-up and droplet coalescence are investigated systematically for a range of viscosity ratio's. For this purpose the droplets are visualized in a counter rotating shear flow cell equipped with a microscope. Concerning for break-up, it was observed that geometrical confinement promotes droplet break-up when the viscosity ratio is above 1, which implies that the critical capillary number for break-up decreases. At viscosity ratio's around one, confinement does not affect the conditions for droplet break-up whereas at viscosity ratio's below 1 the critical capillary number increases with increasing confinement, indicating that confined droplets are stabilized by the presence of the walls. Numerical simulations, using a boundary-integral method, could reproduce and explain these findings.

For coalescence on the other hand the effects of confinement are qualitatively similar for all viscosity ratio's: confinement decreases the coalescence angles and renders coalescence possible up to higher capillary numbers and initial offsets. Moreover, confinement induces a lower initial offset boundary below which the approaching droplets reverse flow direction without coalescence. However, the range of conditions for which coalescence occurs decreases with increasing viscosity ratio. The results are supplemented with finite element numerical simulations in 2D to explain the observations.