Microfluidics to study emulsifier adsorption and emulsion stability

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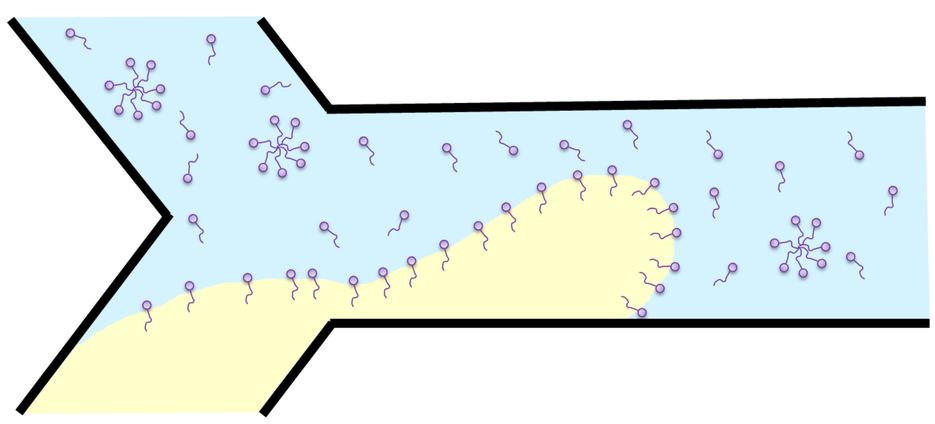
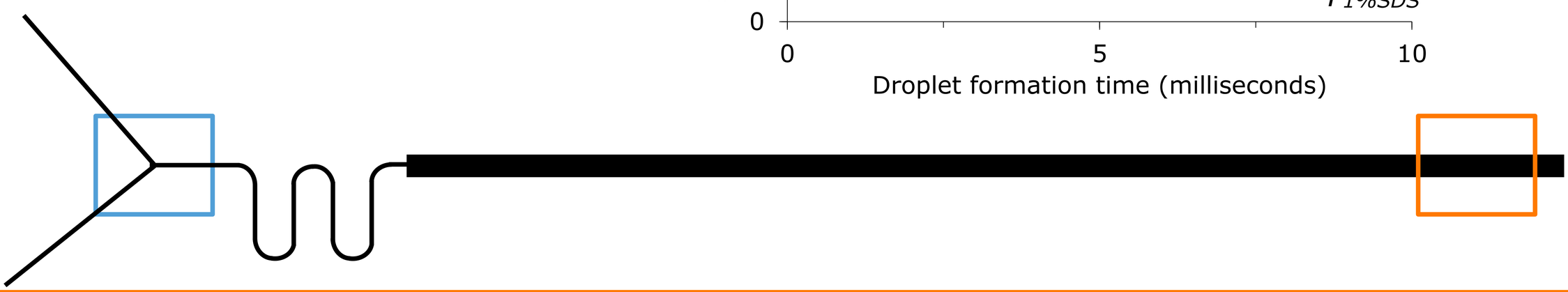
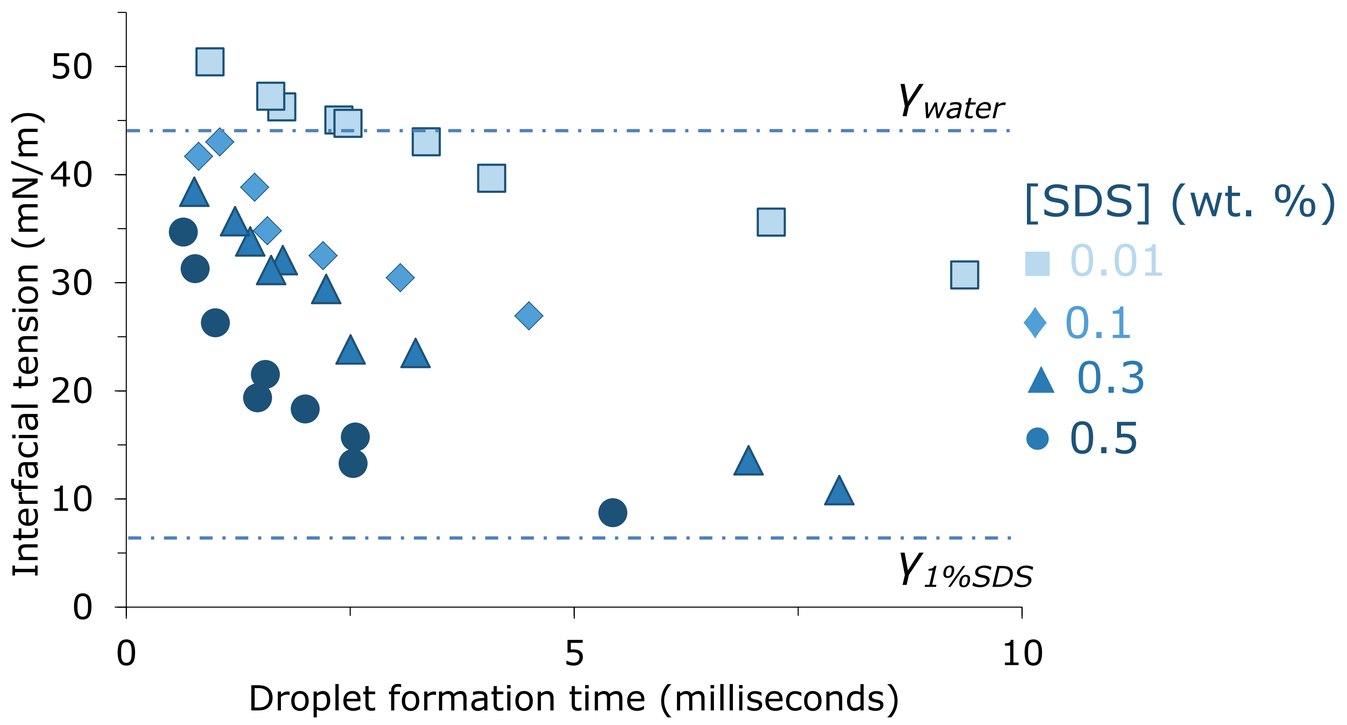
Where food production lines are judged on their throughput, which is often in the order of m^3 per hour, interestingly enough the scale at which a lot of phenomena relevant to food structure take place is much smaller: the micro- and nanometre scale. Microfluidics can be used to bridge this gap, and this work shows that droplet formation and physical stability in food emulsions can be investigated in close detail with high speed recording and image analysis. These analytical methods can help to improve process conditions and can also be used to test product formulations *ab initio*, which can reduce product development time considerably.

Emulsifier adsorption

The interfacial tension during droplet formation was measured in the millisecond range with a microfluidic Y-junction based on the relation between interfacial tension and droplet size. This method allows exploration of surfactant behaviour at the surface of forming emulsion droplets, which is not possible through any other technique at this very short time scale. Interfacial tension was measured for droplet formation times of 0.4 to 9.4 milliseconds for different concentrations of sodium dodecylsulfate (SDS) and decreased with increasing droplet formation time and surfactant concentration, as shown in the figure right below.

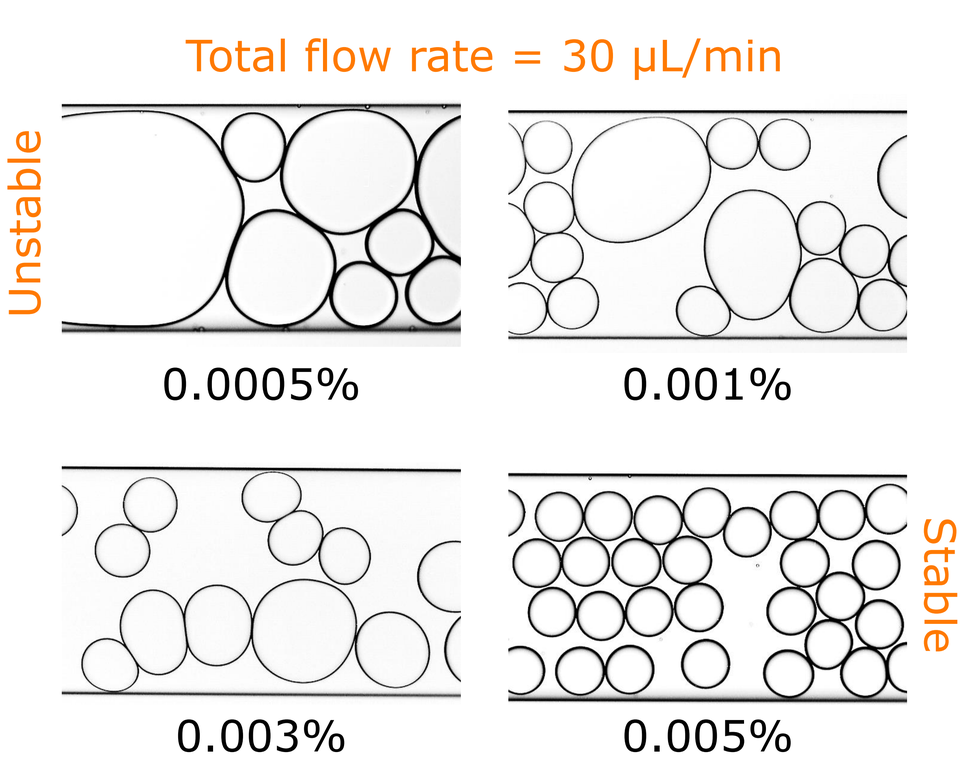


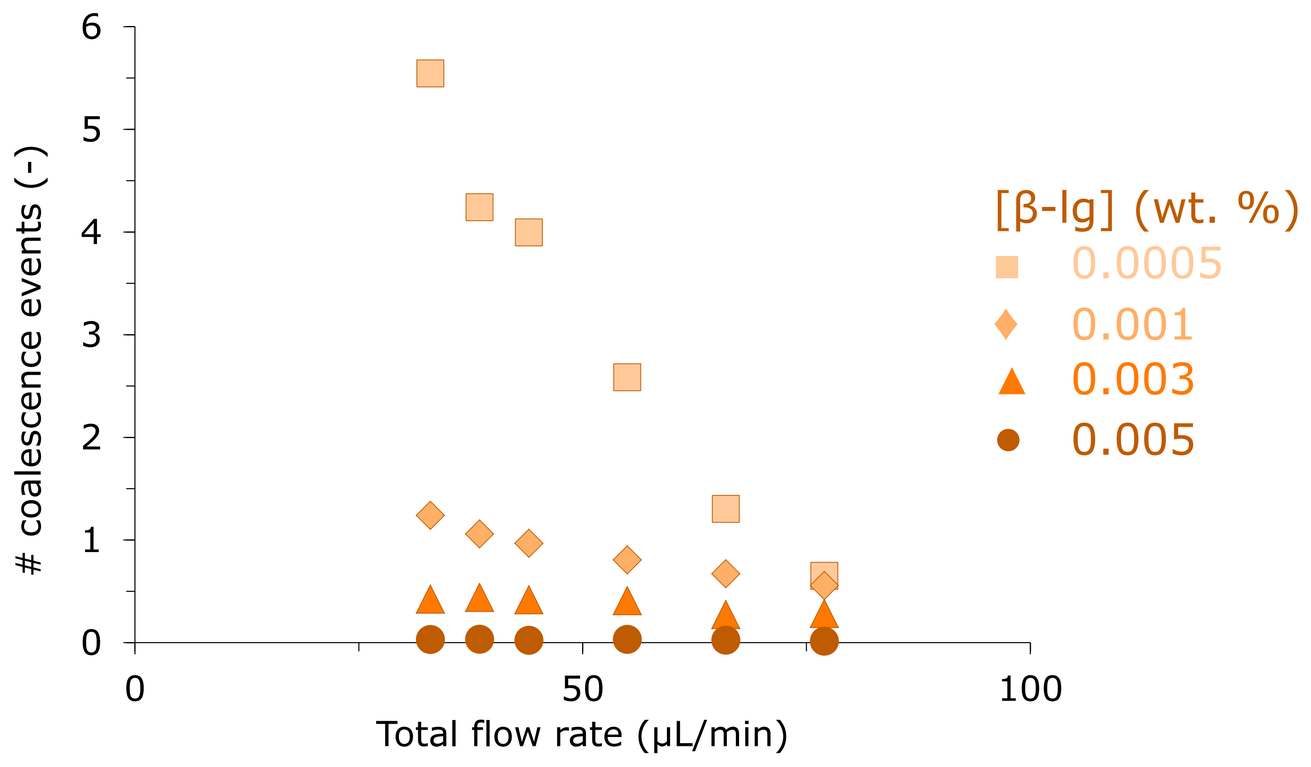




Emulsion stability against coalescence

Droplet coalescence can be measured in detail (in the millisecond time scale and micrometre length scale) in a flowing system (depicted right above) at a relatively high oil volume fraction (30-60%), which is very different from normal stability measurements. After droplet formation, droplets travel through a meandering channel that allows time for protein adsorption after which they enter a wider channel where droplets collide. The microscope images below are taken at the end of the coalescence channel. At relatively high β-lactoglobulin (β-lg) concentration (≥0.005%), emulsions were stable against coalescence, whatever the applied flow rate. Conversely, at lower protein concentrations (<0.005%), the occurrence of coalescence decreased with increasing flow rate because droplet interaction was not slow enough to allow for film rupture.





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