Dynamic interfacial tension of emulsions studied with microfluidics

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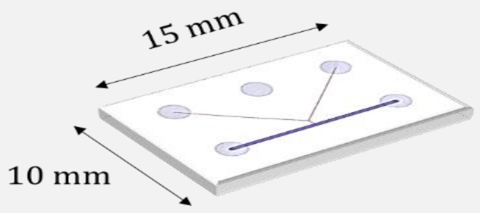
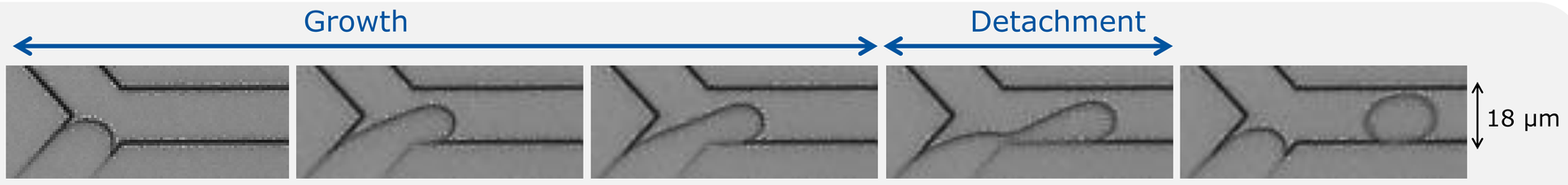
During emulsification processes oil droplets are formed and new interface is created, which needs to be stabilised by proteins and/or surfactants before the droplets interact and possibly coalesce as a result. An indication for stabilisation is a decrease in interfacial tension; however, droplet formation occurs within milliseconds while conventionally interfacial tension can only be measured in the range of seconds. To better understand stabilisation during emulsification, it is crucial to investigate in the millisecond range, and for this microfluidics in combination with high speed recording is ultimately suited. Here we show the dynamic interfacial tension of sodium dodecyl sulphate and whey protein isolate in the sub-millisecond range based on a relation between the interfacial tension and the droplet size established in microfluidics, and interpret the results.

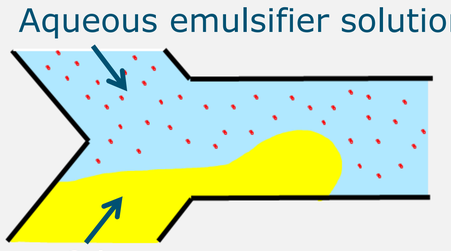
Experimental set-up





$$V = V_{growth} + V_{detachment} = V_{crit,ref}\left(\frac{\gamma}{\eta_d v_c}\right)^x + \varphi_d\, t_{detach,ref}\left(\frac{\gamma}{\gamma_0}\right)^x$$

Aqueous emulsifier solution



Oil

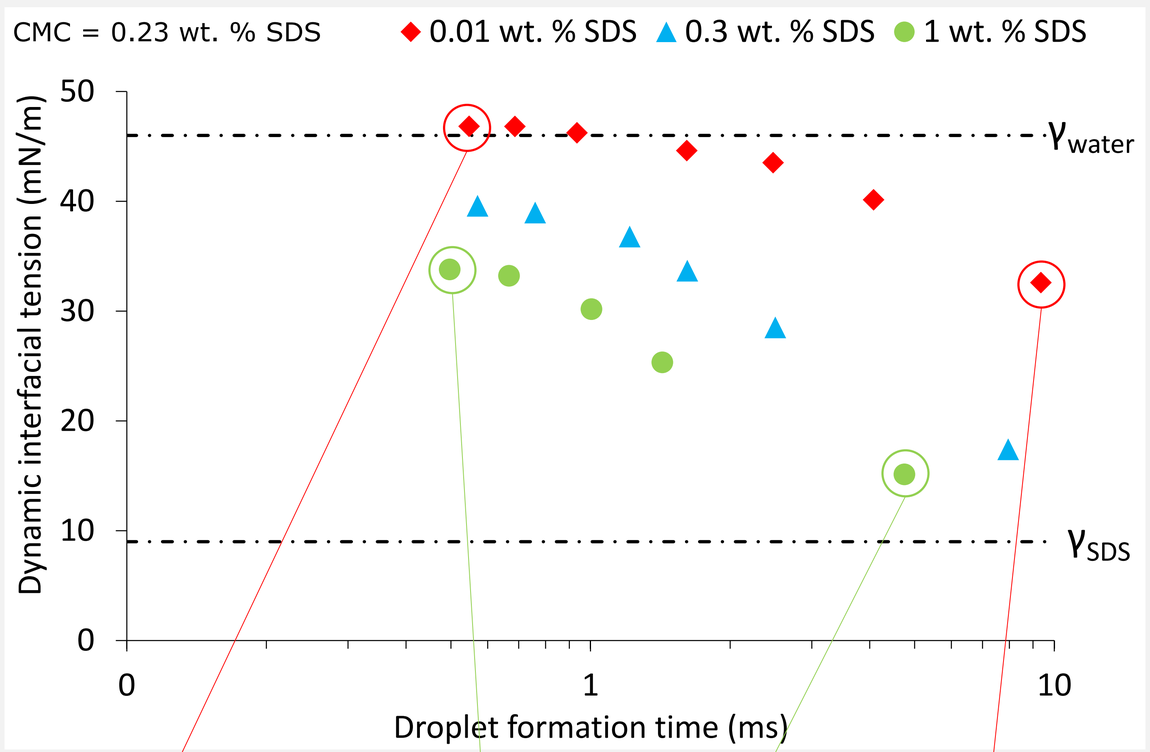
Droplet volume (V)
Continuous phase velocity (v_c)
Disperse phase flow rate (φ_d)

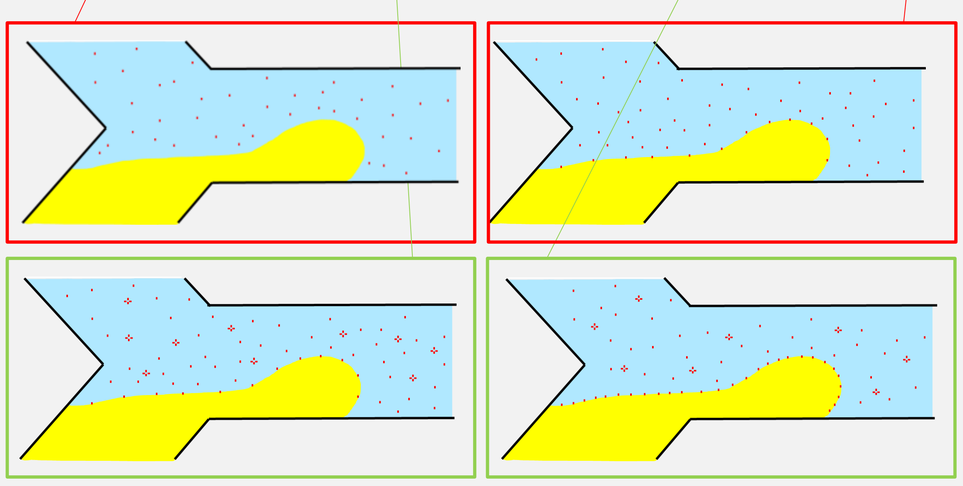
Interfacial tension hexadecane-water (γ_0)
Disperse phase viscosity (η_d)
Fitted parameters ($V_{crit,ref}$, $t_{detach,ref}$, x)

$$\gamma_d = \left(\frac{V}{\frac{V_{crit,ref}}{(\eta_d v_c)^x} + \frac{t_{detach,ref}\,\varphi_d}{\gamma_0{}^x}}\right)^{x^{-1}}$$

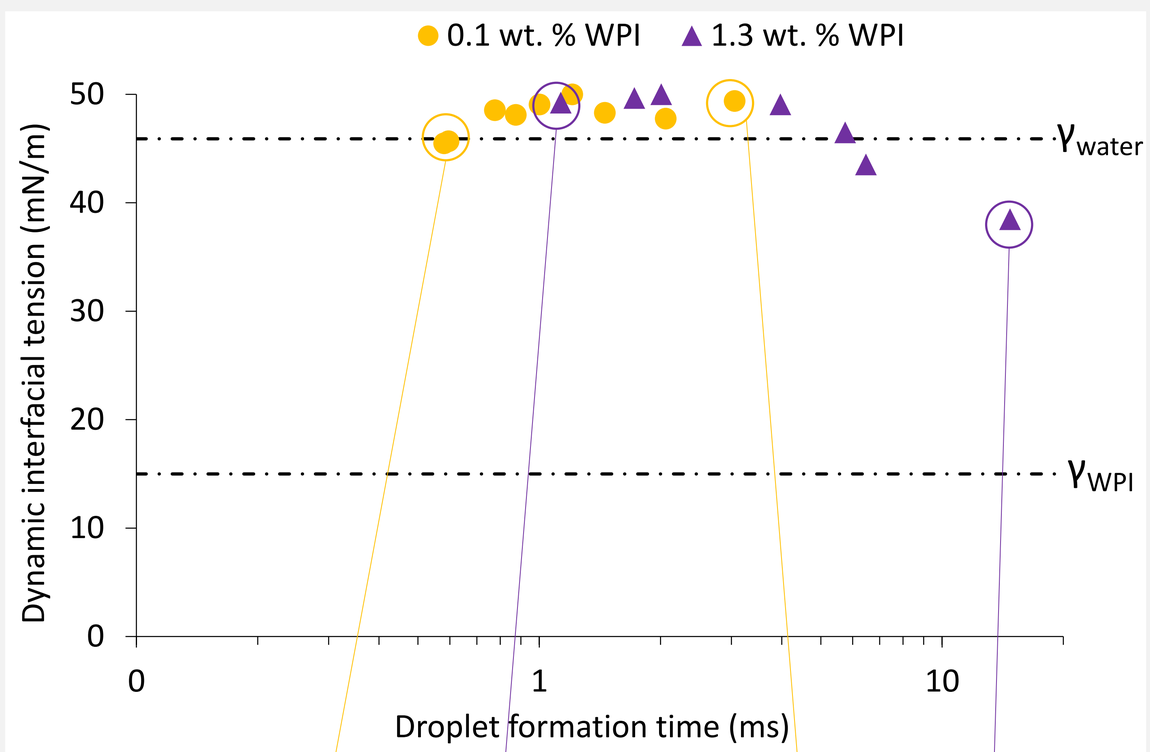
→ Dynamic interfacial tension

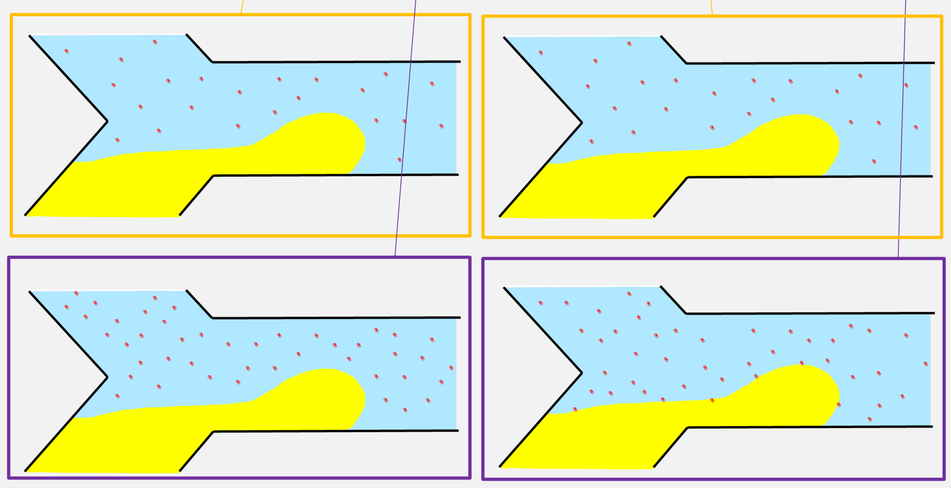
Sodium dodecyl sulphate
Low molecular weight emulsifier





Whey protein isolate
High molecular weight emulsifier





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