

Dynamic interfacial tension of emulsions studied with microfluidics

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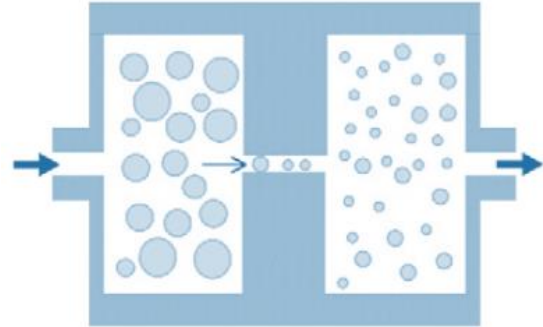


Acknowledgements

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Emulsifier adsorption

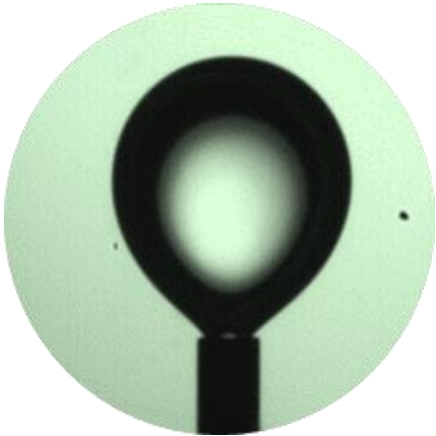


Industrial emulsification

Turbulent flow

Convective mass transfer

Time scale: sub-milliseconds



Drop tensiometer

No flow

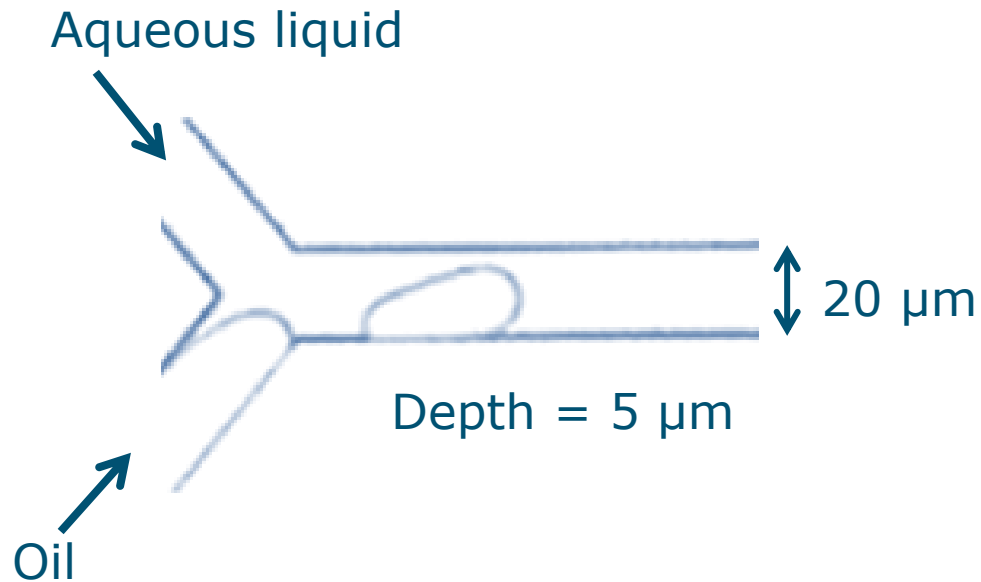
Diffusive mass transfer

Measurement: seconds



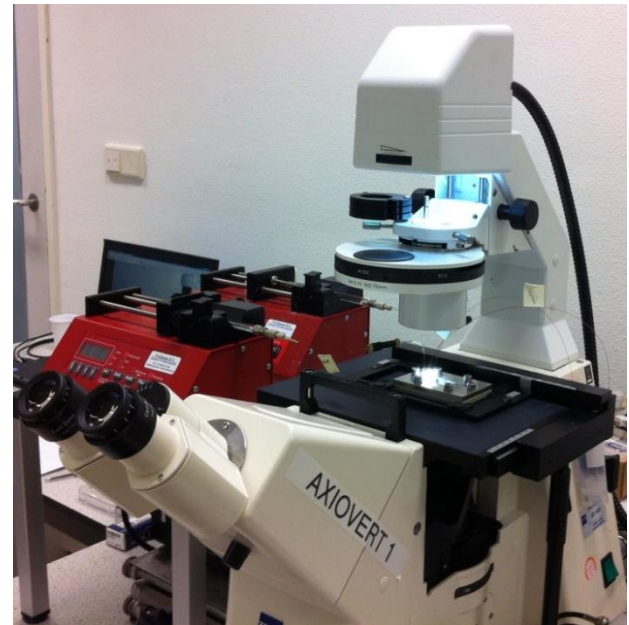
Microfluidic Y-junction

Microfluidic Y-junction

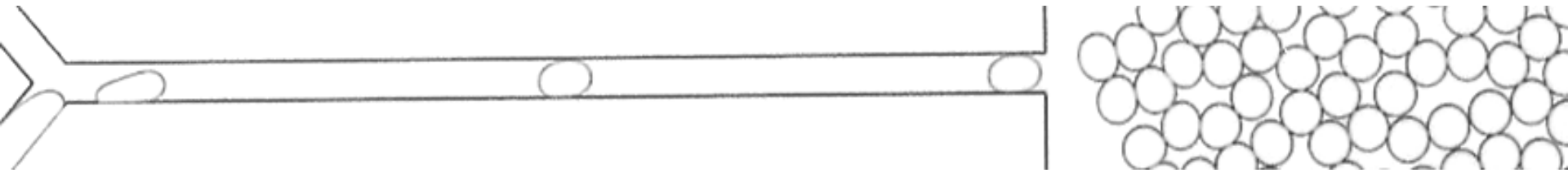


Measure with image analysis

- Droplet size
- Dispersed phase flow rate
- Continuous phase velocity



Microfluidic Y-junction

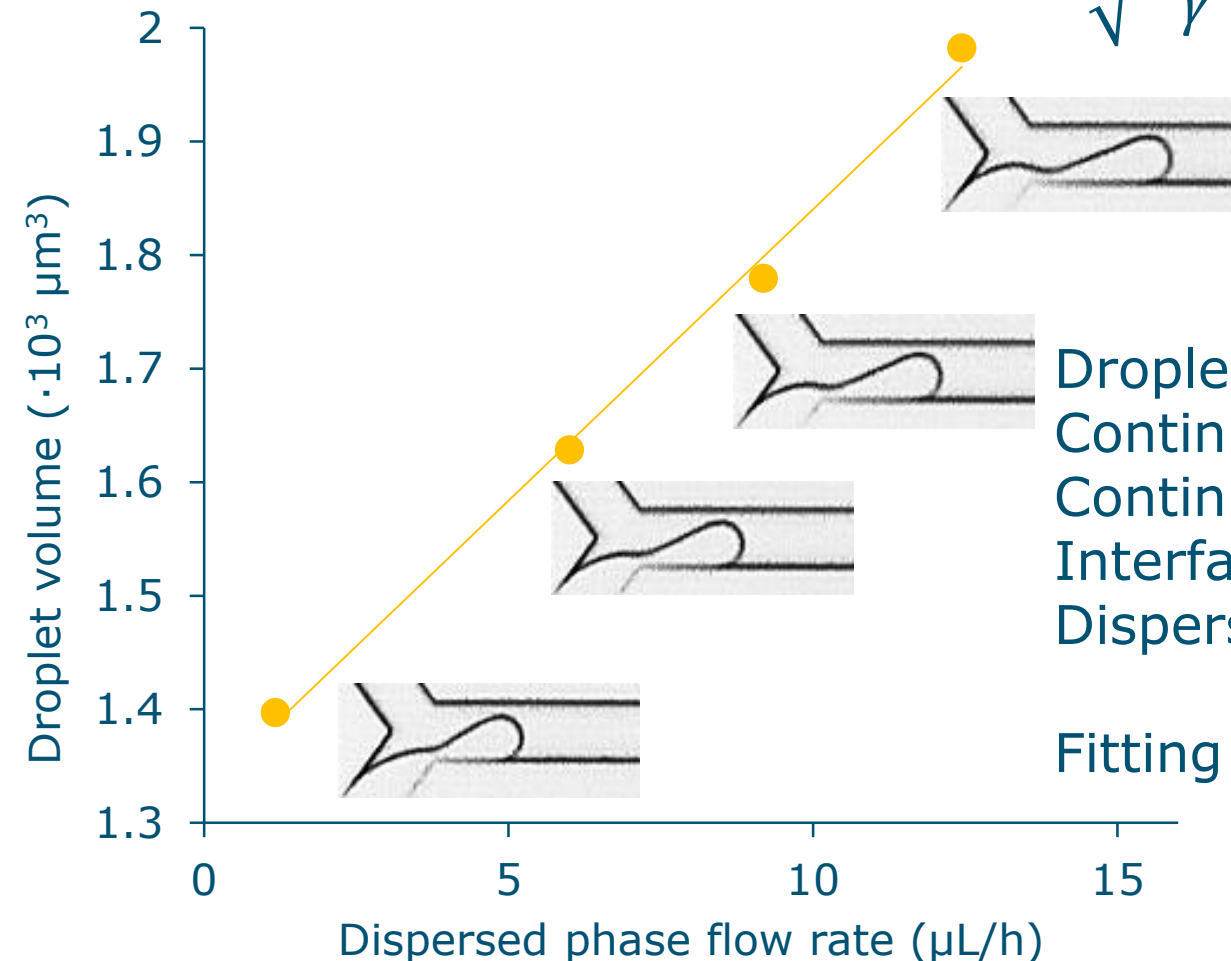


Droplet formation is a balance between shear force and interfacial tension

Two-step model

Hexadecane droplets formed in water

$$V = V_0 + \text{constant} \cdot \varphi_d = \frac{b}{\sqrt{\frac{\eta_c v_c}{\gamma}}} + \frac{c}{v_c} \varphi_d$$

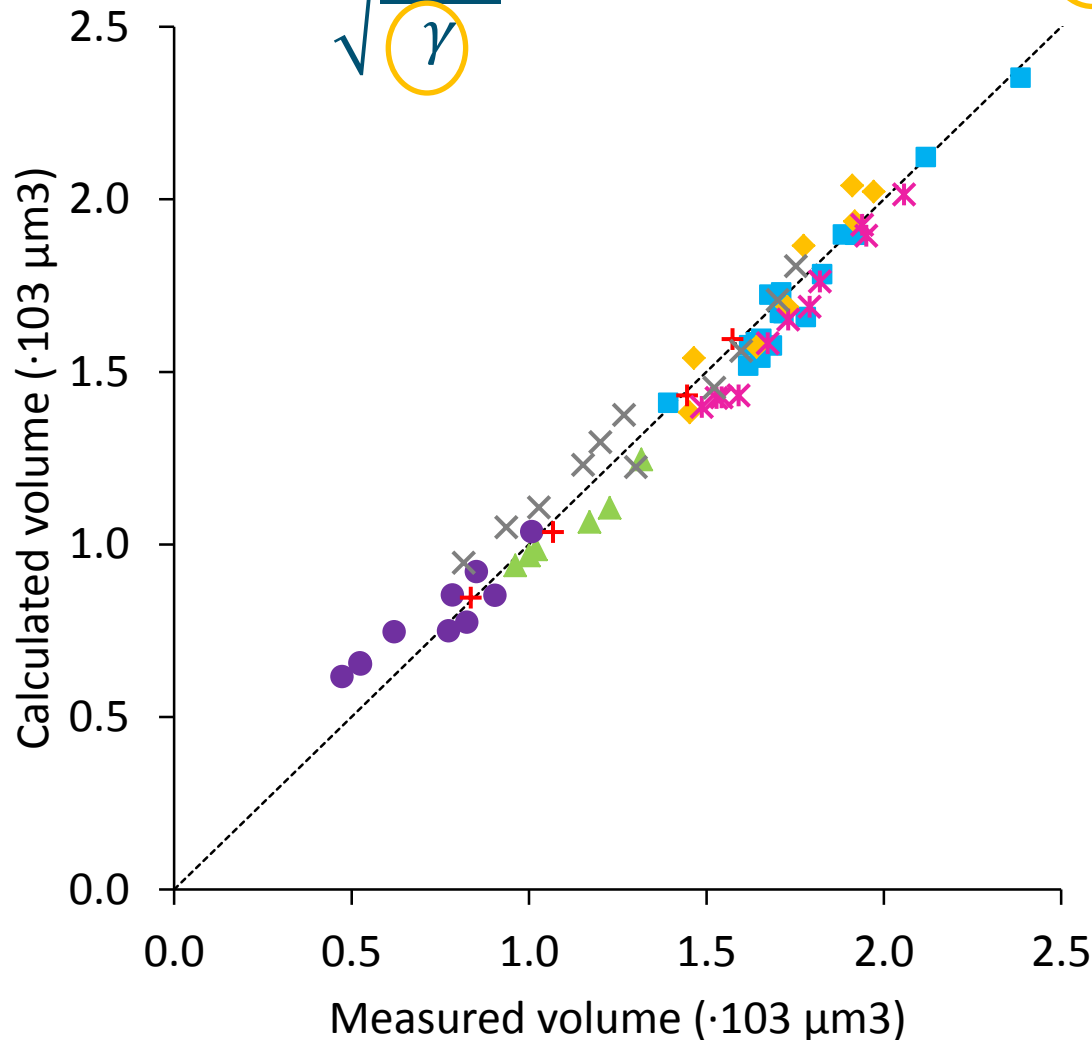


Droplet volume (V)
Continuous phase velocity (v_c)
Continuous phase viscosity (η_c)
Interfacial tension (γ)
Dispersed phase flow rate (φ_d)

Fitting parameters: b and c

Validation

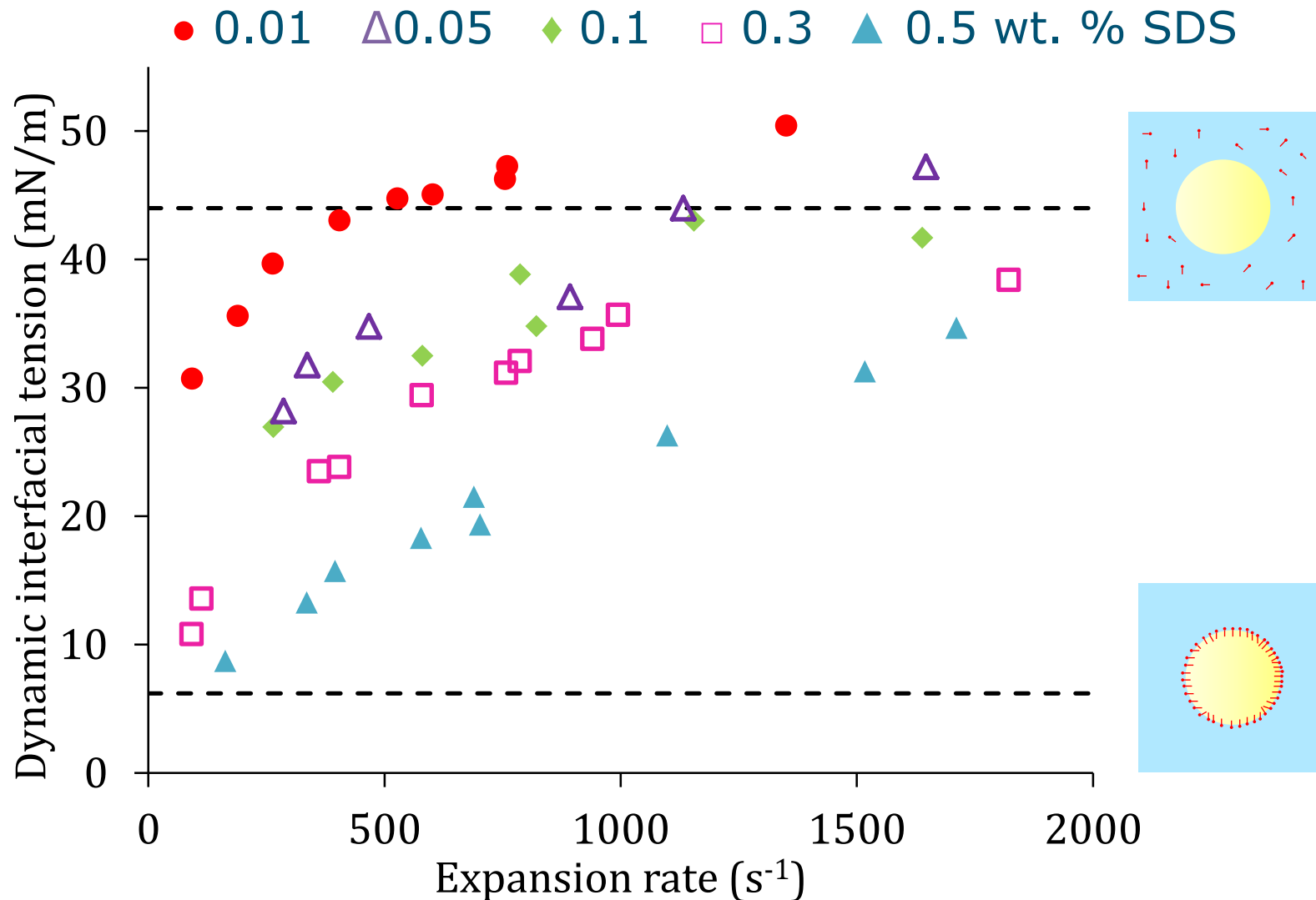
$$V = \frac{b}{\sqrt{\eta_c v_c}} + \frac{c}{v_c} \varphi_d \quad \longrightarrow \quad \gamma = \eta_c v_c \left(\frac{V - \frac{c}{v_c} \varphi_d}{b} \right)^2$$



Continuous phase	η_c (mPa s) 20 °C	$\gamma_{\text{hexadecane}}$ (mN/m) 20 °C
■ Water	1.0	46
▲ 9% ethanol	1.5	27
● 28% ethanol	2.5	15
◆ 20% glycerol	1.8	37
+ 30% glycerol	2.6	35
* 20 % sucrose	2.1	47
× 25 % sucrose	2.4	47

Dynamic interfacial tension

Sodium dodecylsulphate (SDS)

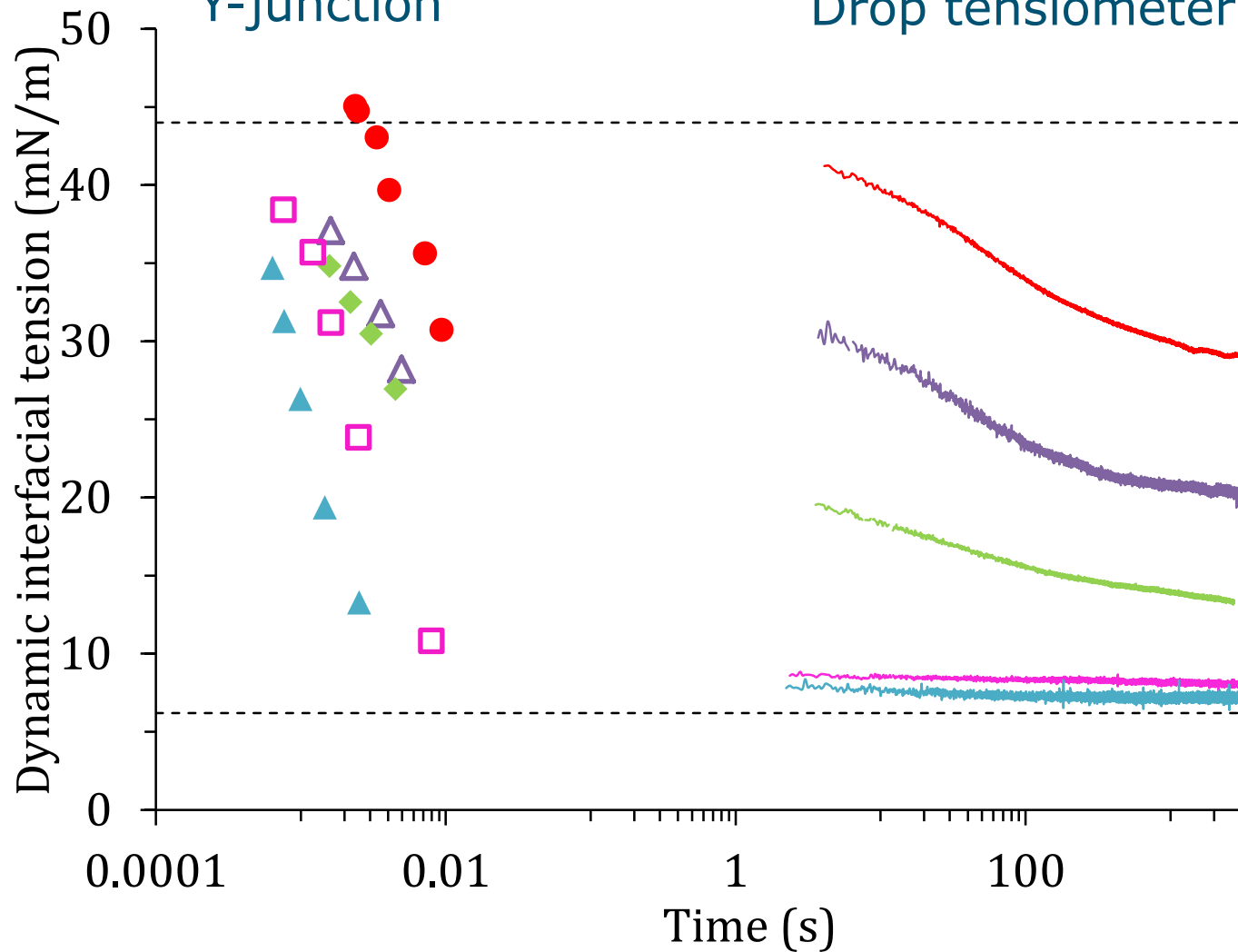


Adsorption dynamics

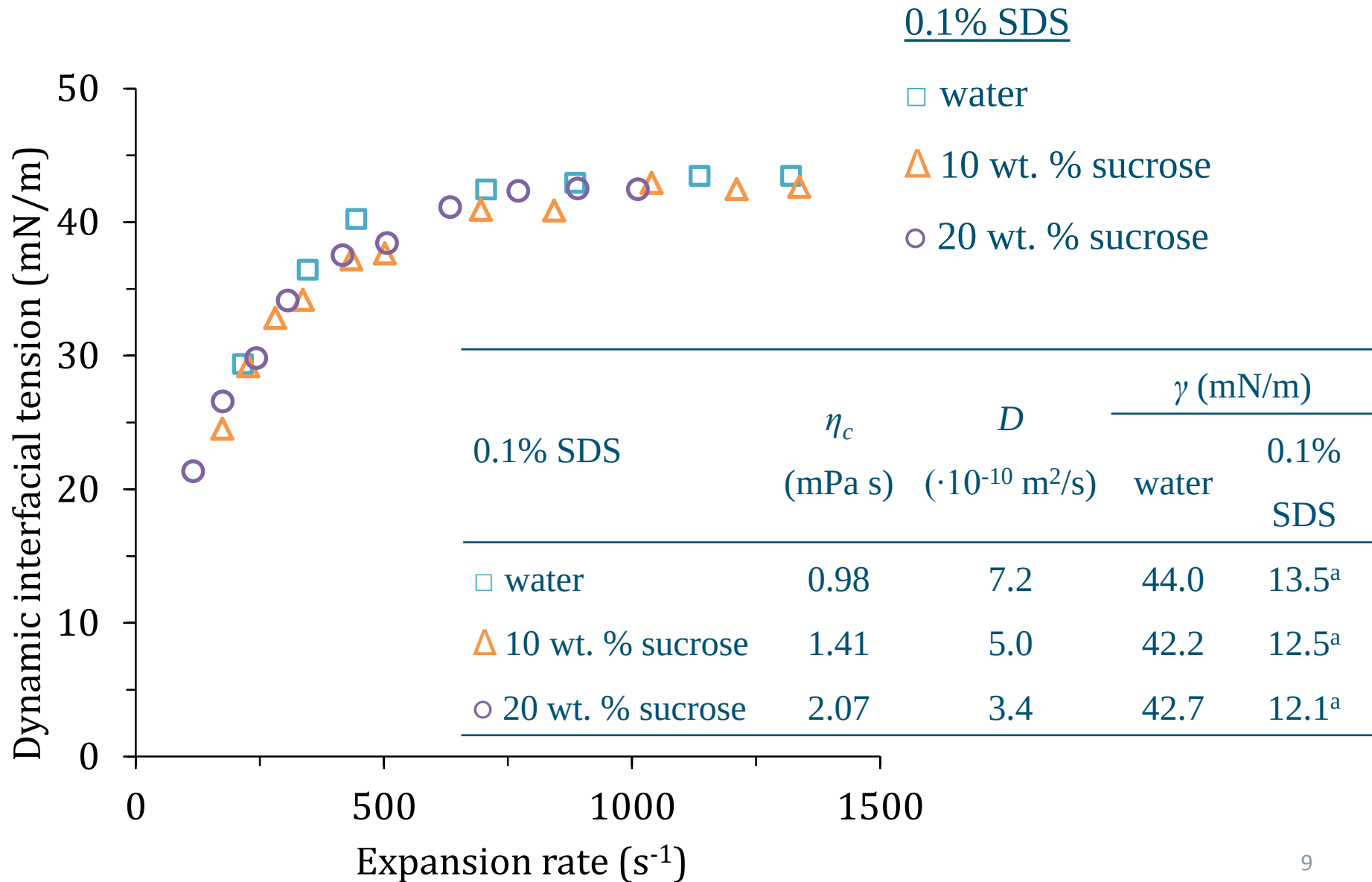
● 0.01 △ 0.05 ◆ 0.1 □ 0.3 ▲ 0.5 wt. % SDS

Y-junction

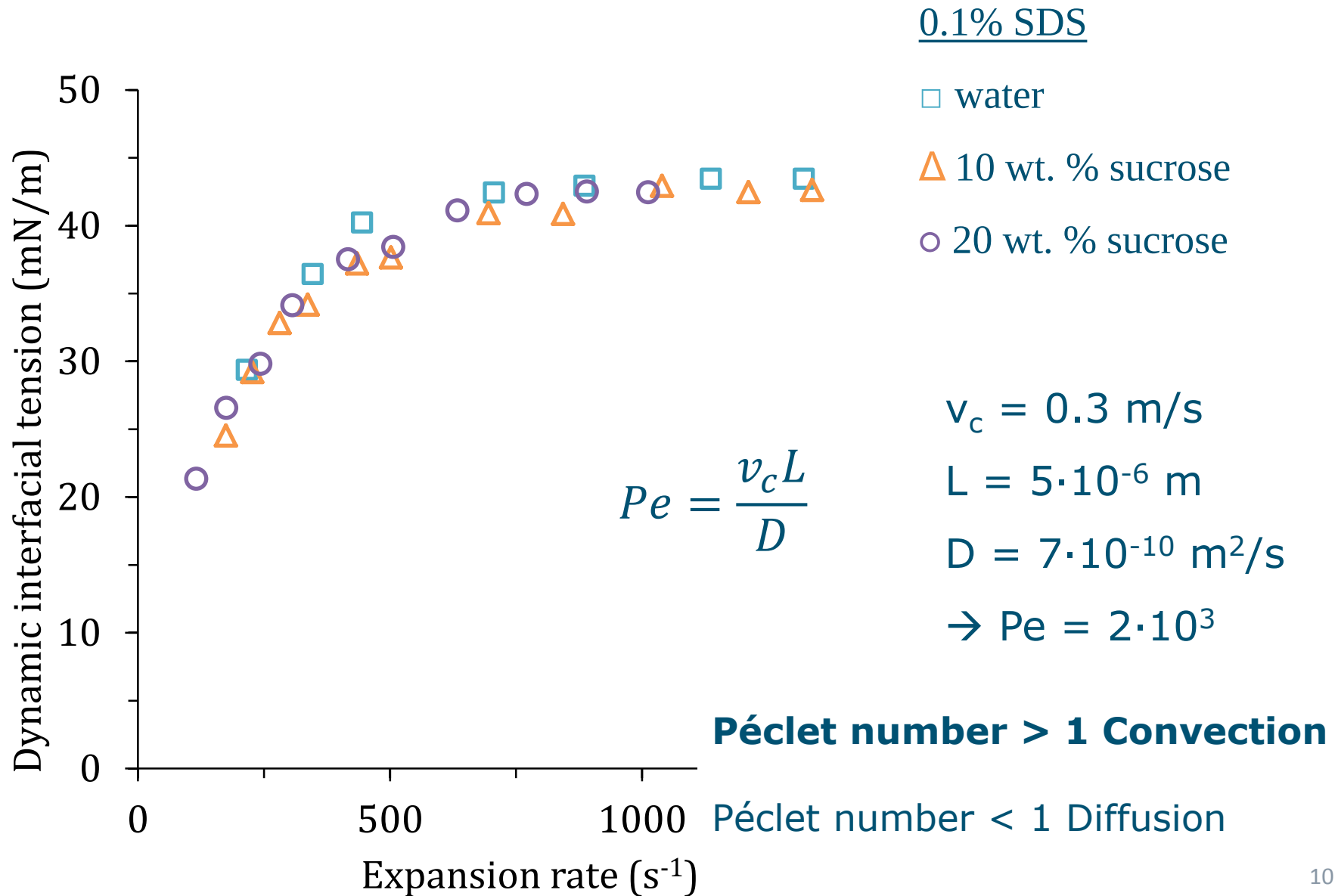
Drop tensiometer



Continuous phase viscosity

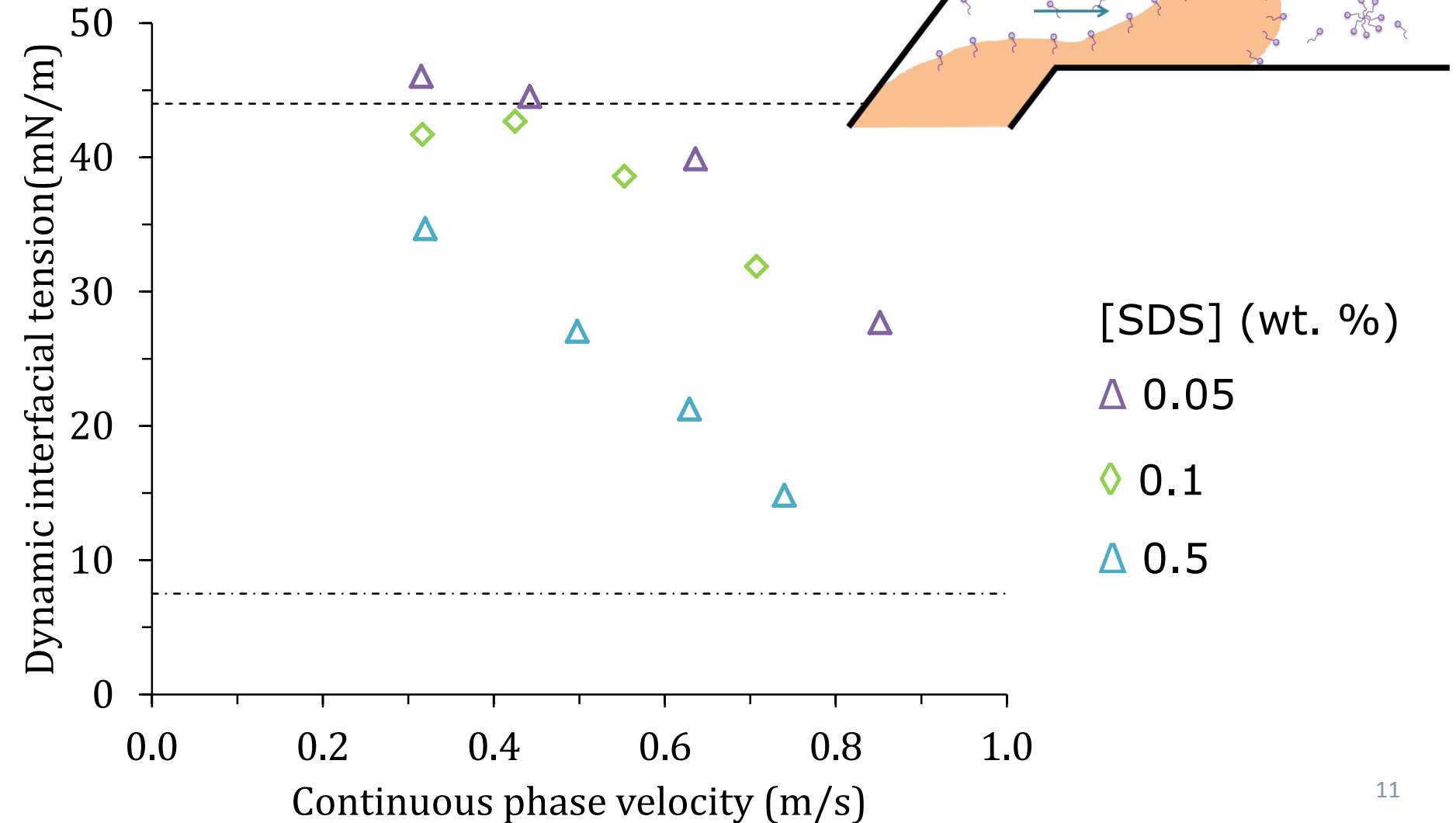


Continuous phase viscosity

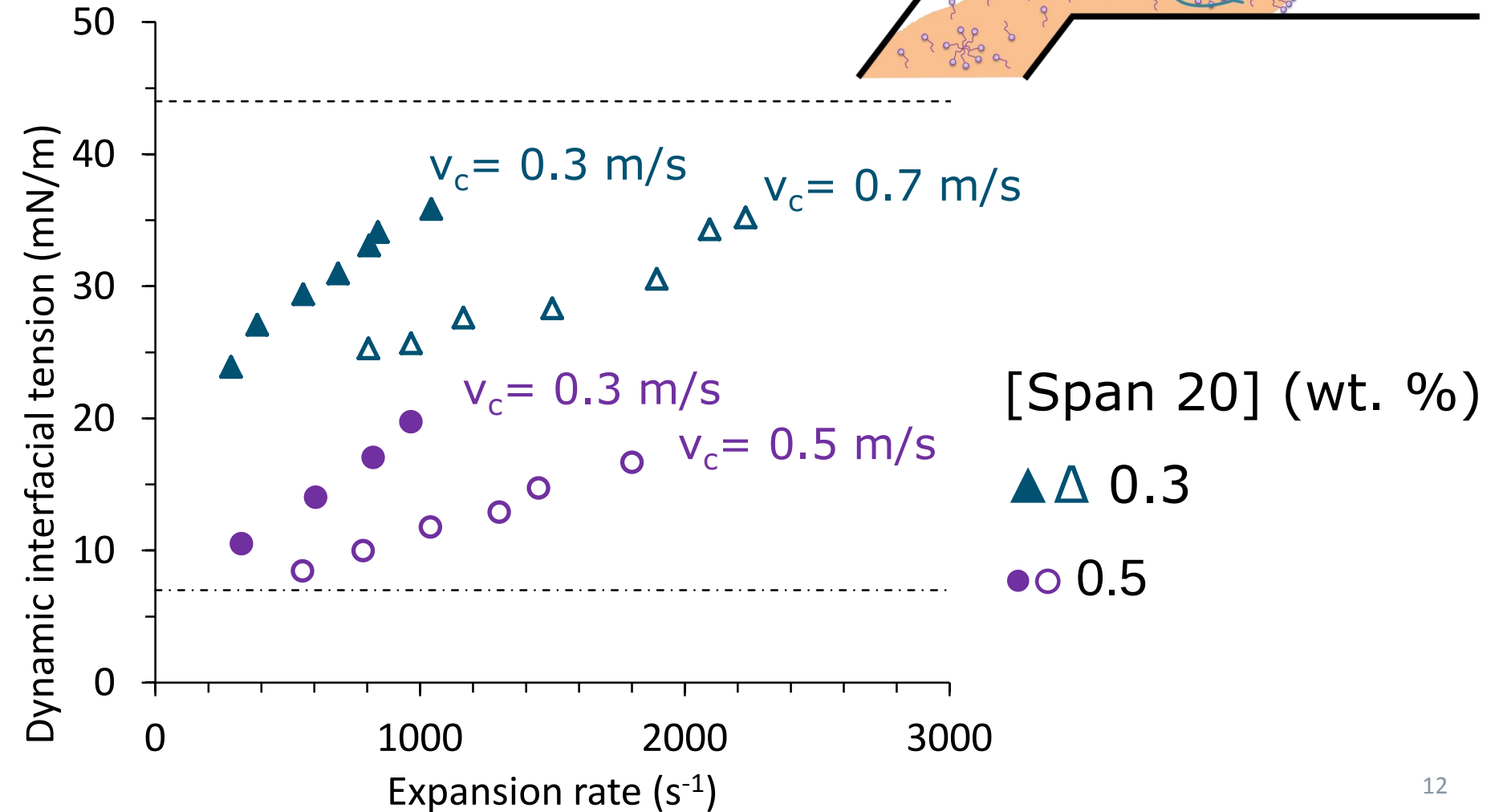
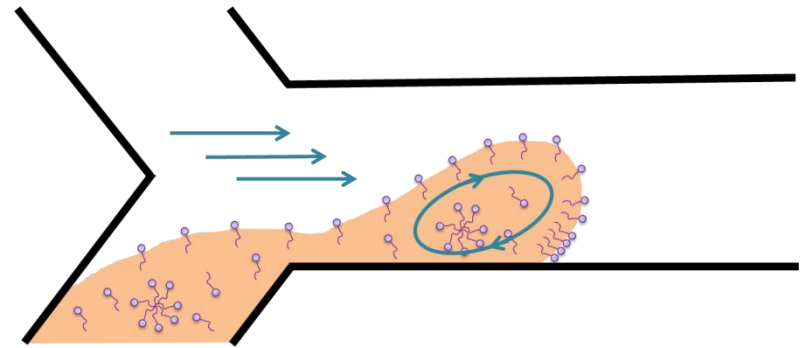


Continuous phase velocity

Expansion rate = $1488 \pm 263 \text{ s}^{-1}$



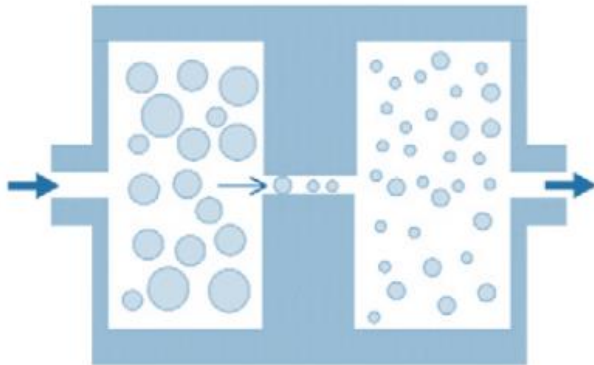
Continuous phase velocity



Highlights

Microfluidic method to measure interfacial tension

- At high expansion rates
- Within milliseconds
- Mass transfer is determined by continuous phase velocity



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