Effect of bubble size on the stability of flowing liquid films in binary oil mixtures

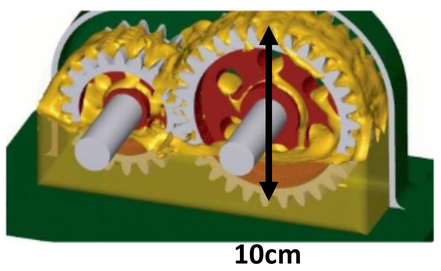
Ange Combrouze[1,2,3], *A. Klimenko*[2,3], *P. Panizza*[1,2], *F. Lequeux*[1,2], *L. Talini*[4], *E. Verneuil*[1,2]

[1] Soft Matter Sciences and Engineering (SIMM), ESPCI Paris, PSL University, Sorbonne Université, CNRS, F-75005 Paris, France
[2] Laboratoire Physico-Chimie des Interfaces Complexes, Bâtiment CHEMSTARTUP, 64170 Lacq, France
[3] TotalEnergies One Tech, Pole d'Etudes et Recherche de Lacq, BP 47-64170 Lacq, France
[4] CNRS, Surface du Verre et Interfaces, Saint-Gobain, 93300 Aubervilliers, France.

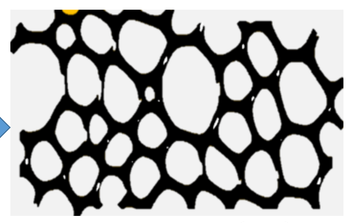
Context and stakes

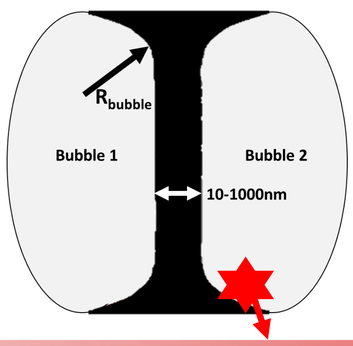
- ***Real Life***

Motor lubricants
Separators & Pipe



- ***Macro scale***



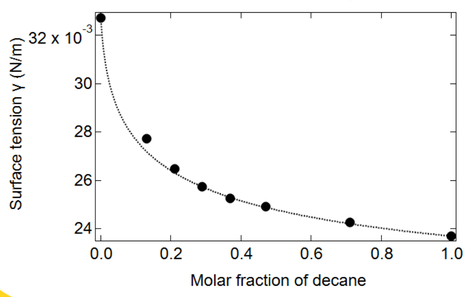


- ***Elementary interfacial scale***

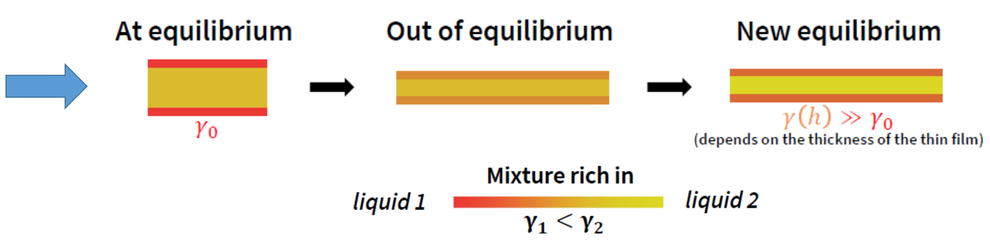
Evolution of film stability with **bubble size R_{bubble}** and **varying composition**?

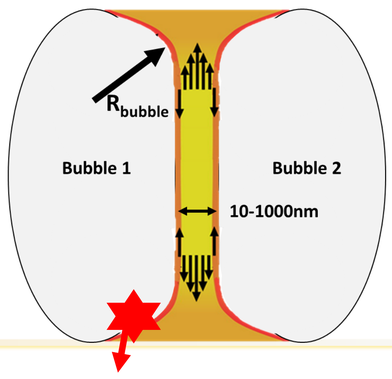
Origin of life-time extension of thin films of mixtures [1]

- ***Species with lowest γ is more concentrated at surface than bulk.***



- ***Stretching the thin liquid film at constant volume causes thinning and a surface tension gradient.***





Foam drainage driven by capillary pressure is partially compensated by Marangoni flow at interface between gas and liquid.

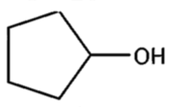
$\tau_{mixtures} \sim 10^4 * \tau_{pure\ liquids}$

(G. Debrégeas, P.-G. de Gennes and F. Brochard-Wyart, Science, 1998, 279, 1704–170)

Material & Methods

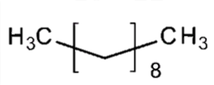
- ***Foaming <u>without surfactants</u>***

Cyclopentanol
$C_5H_{10}O$



$\gamma \sim 33 mN/m$
$\eta \sim 10 mPa.s$

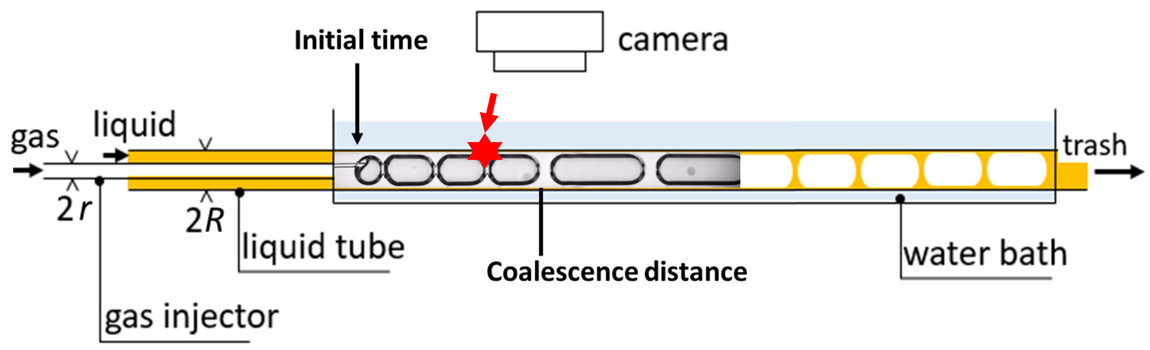
Decane
$C_{10}H_{22}$



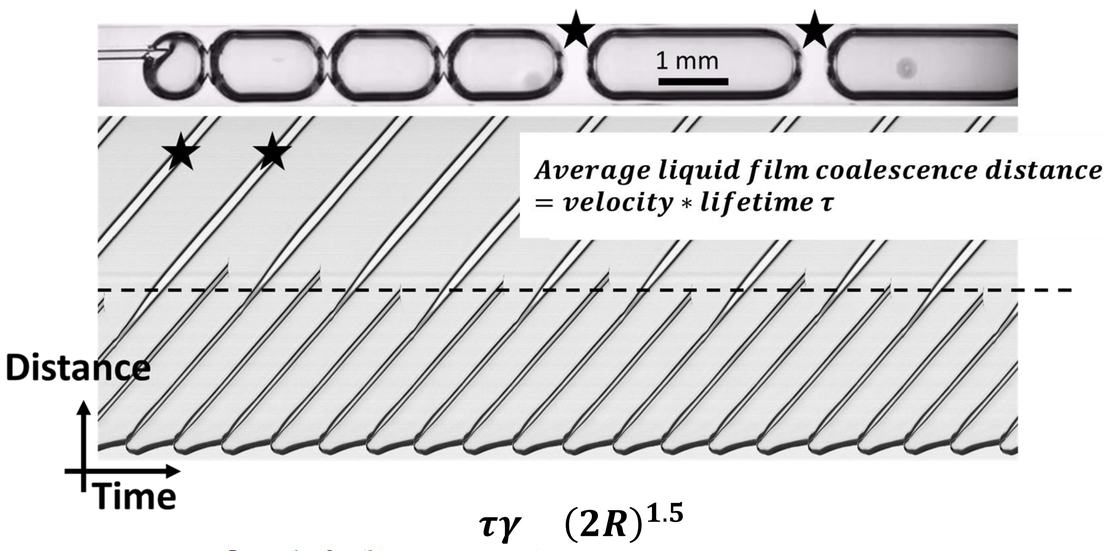
$\gamma \sim 24 mN/m$
$\eta \sim 1 mPa.s$

Foaming dependent on mixture composition
(H.P. Tran, thesis, 2022)

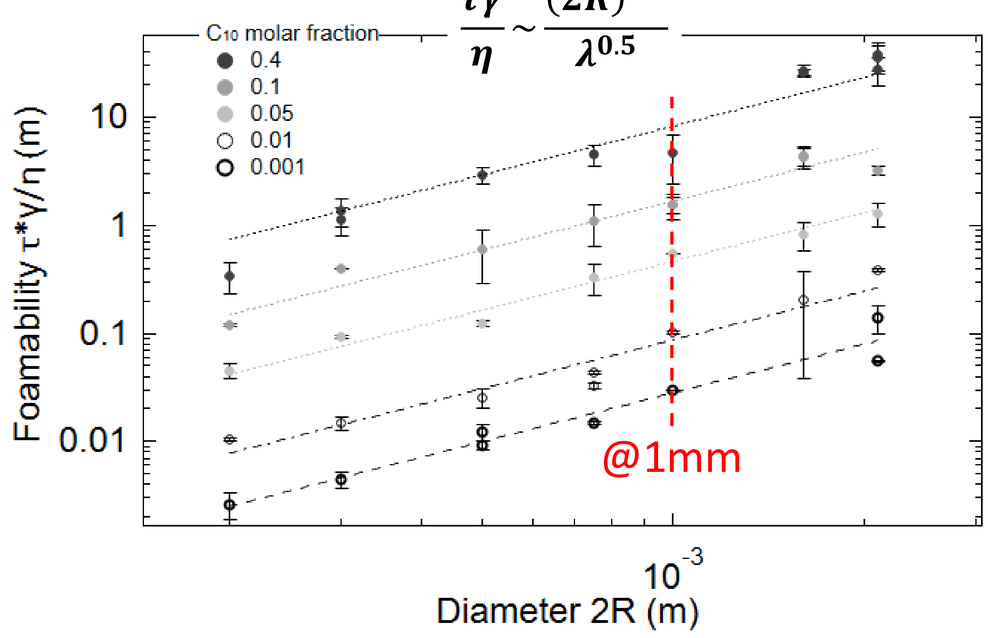
- ***Millifluidic set-up* to vary <u>bubble size over one decade</u>**

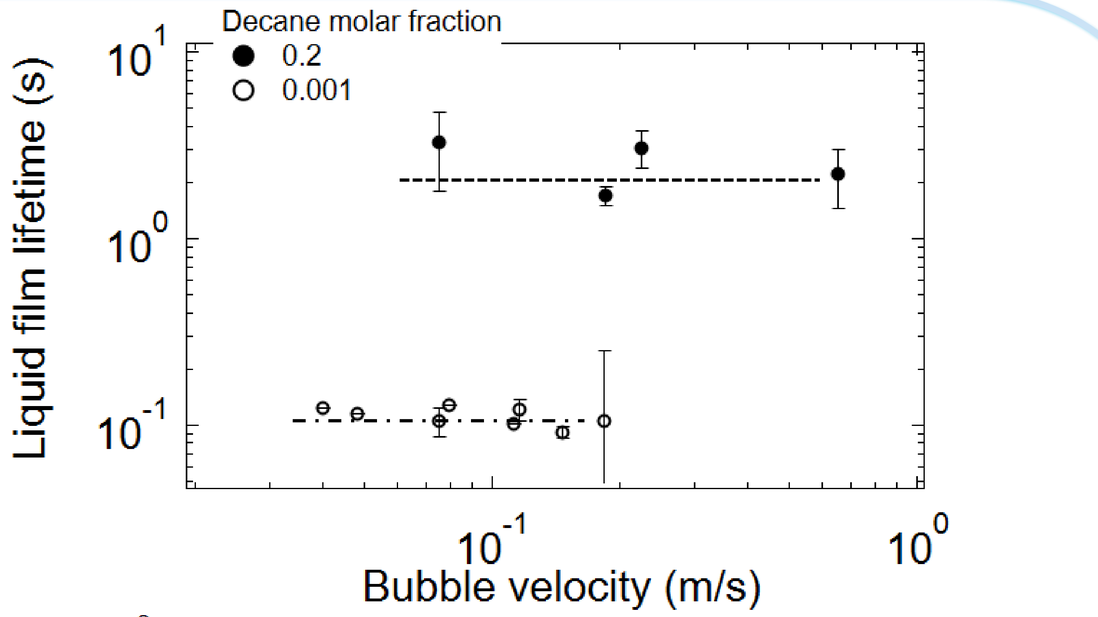


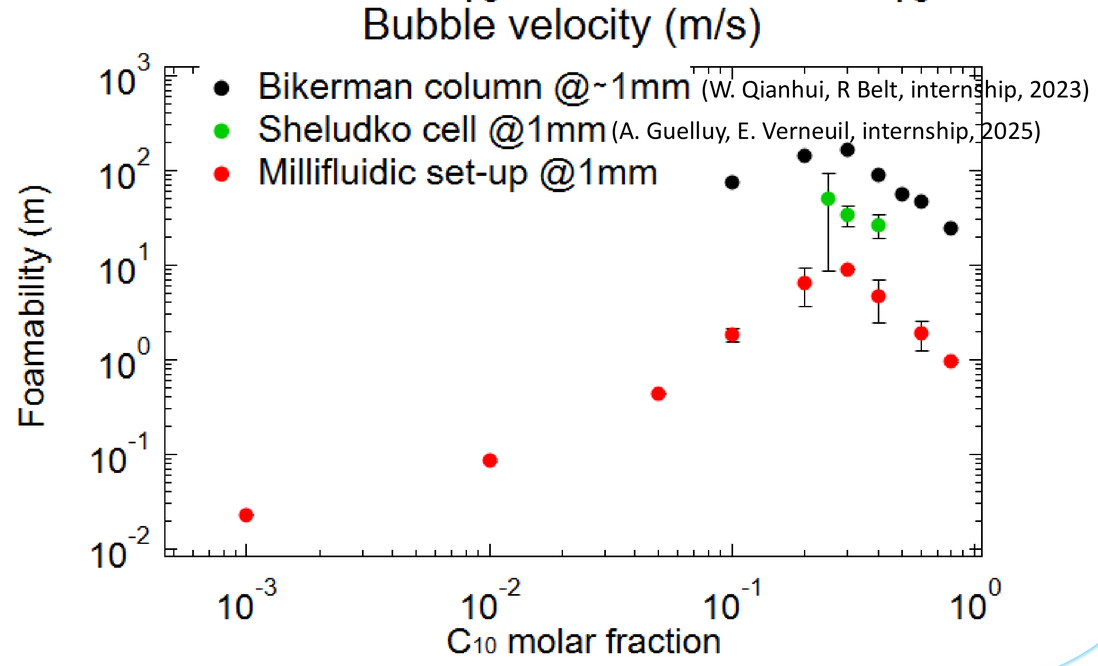
Results & Discussion



$$\frac{\tau\gamma}{\eta} \sim \frac{(2R)^{1.5}}{\lambda^{0.5}}$$







Conclusion:

$$\frac{\tau\gamma}{\eta} \sim \frac{(2R)^{1.5}}{\lambda^{0.5}}$$

- Length λ is intrinsic to the binary oil mixture's physico-chemical properties and characterizes its foamability.
- Lifetime τ increases with bubble size following a power law in 1.5, regardless of the mixture composition.

References:

[1] H.P. Tran, thesis, 2022
[2] W.Qianhui, R.Belt, internship, 2023

Contact: ange.combrouze@espci.fr