Two drops tensiometer using drops with and without apex:
- Mass transfer between drops
- Surfactant Desorption in a liquid bridge

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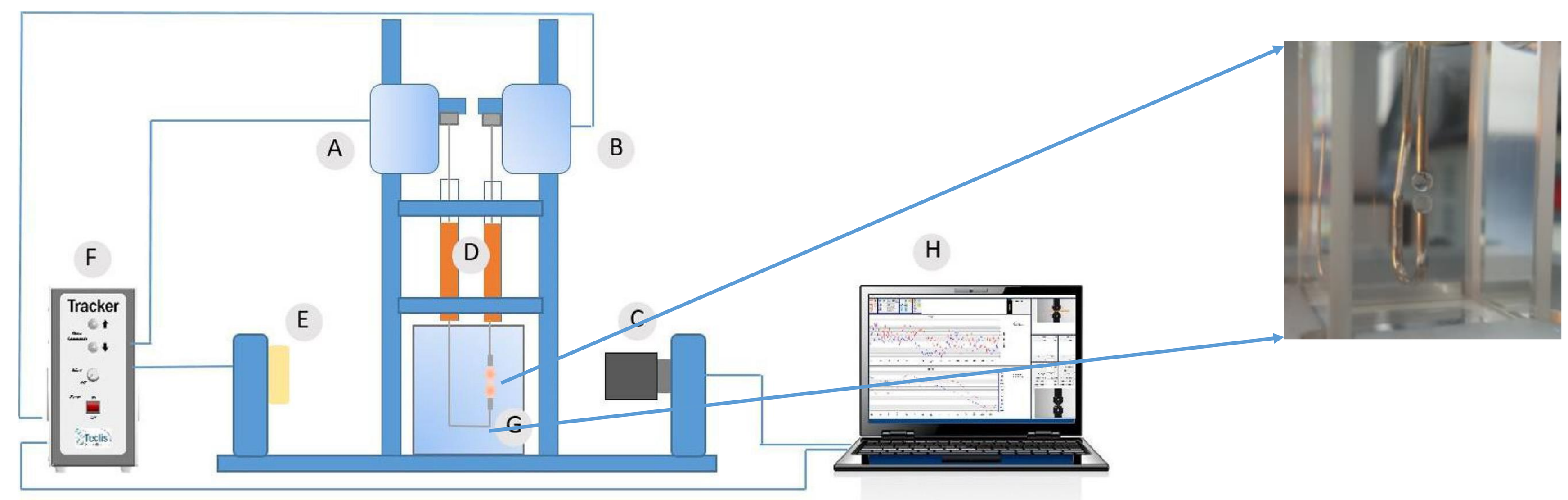
Objectives & Context

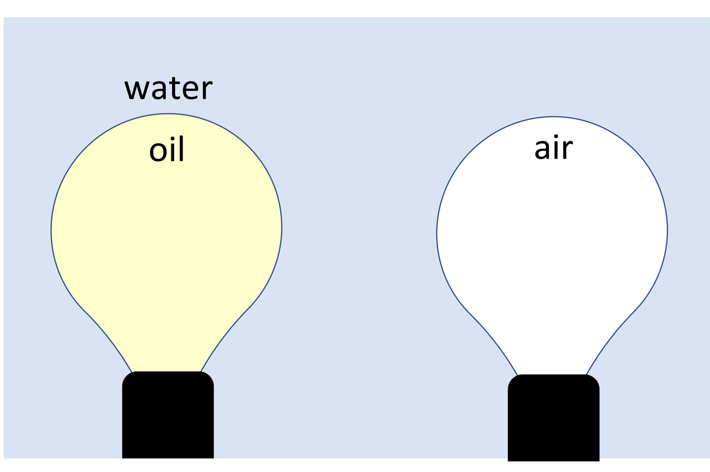
We have developed a new instrument to measure simultaneously the interfacial tension and interfacial dilatational rheology of two Bubbles or Drops immersed in the same liquid. It is possible to put it in contact and characterize the interaction between these Bubbles and/or Droplets.

The device used is an implementation of the original Tracker device by Teclis. It includes two sets of syringe pumps allowing to form the drops at the end of vertical needles. The drops face each other vertically and are immersed in a cuvette containing the second phase (air or another liquid). Liquid bridges are then formed between two drops.

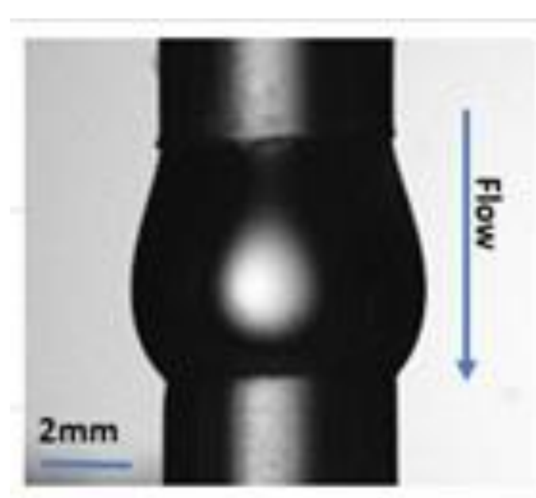


The interfacial properties are determined from the shape of a drop or of a liquid bridge formed between two approaching drops.

Methods



Two drops tensiometer: two drops in the same bulk phase where, the drops volumes and oscillations can be controlled independently of each other. The surface tension is read by automated drop shape analysis for each drop and simultaneously.
The second drop as probe: When the first drop is made of oil and the second is an air bubble, this later can be used as a probe for surface active molecules released from the oil drop into the bulk.



Liquid Bridge: When a bridge is formed, thanks to the motor regulation, it is possible to circulate a flow of liquid between the two syringes while imposing a constant volume of the liquid bridge. One can thus replace the liquid in the bridge by another liquid.

Material

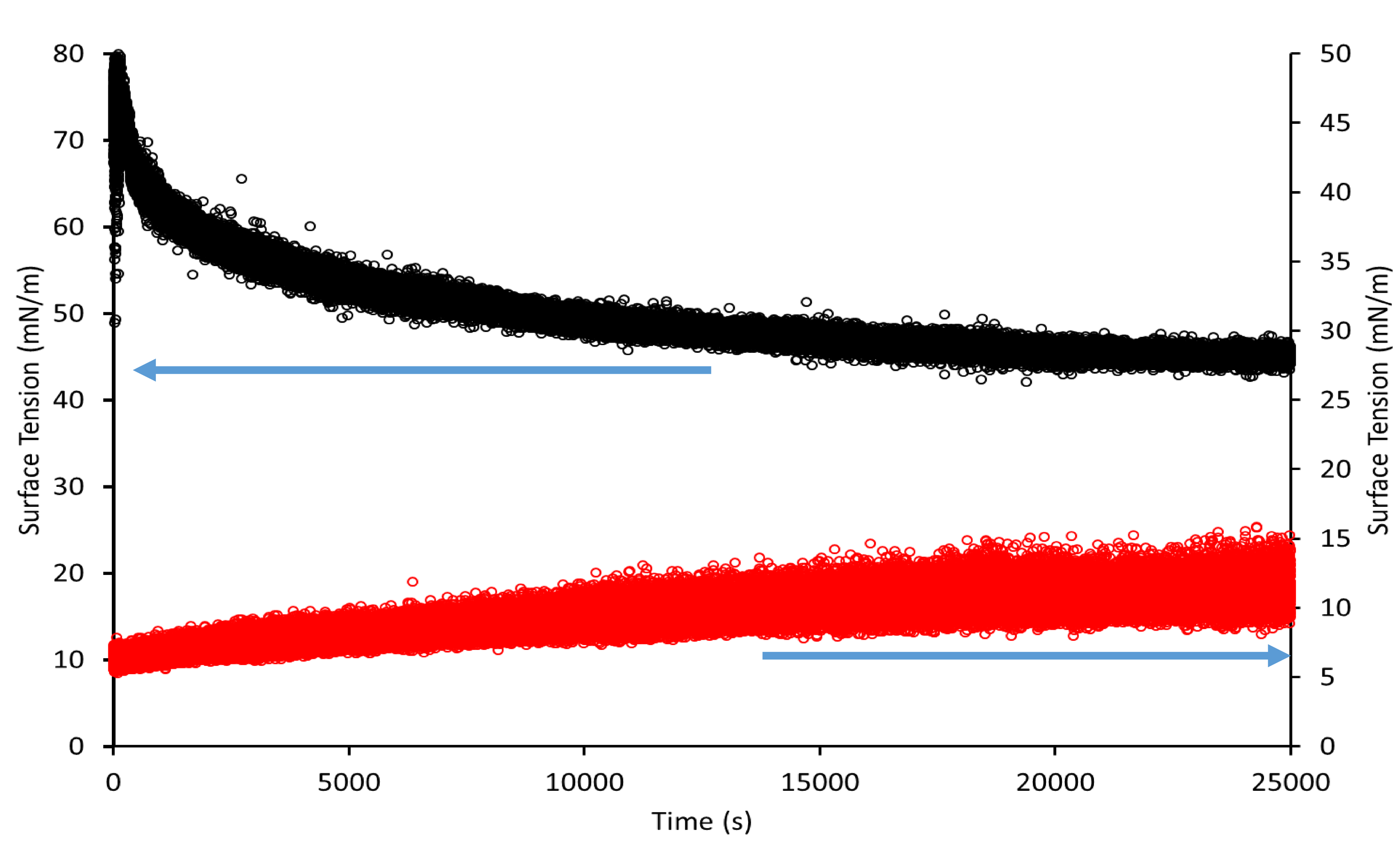
Two drops tensiometer:
Drop of trioctanoin with non-ionic surfactant $C_{10}E_5$ and an air bubble, both formed in pure MilliQ water

Liquid Bridge:
⇨ 0.015 g/l C12E5 in aqueous solution
⇨ 100 mM hexadecyl trimethyl ammonium bromide (CTAB) in aqueous solution with 50 mM sodium bromide NaBr.

All measurements at ambient temperature.

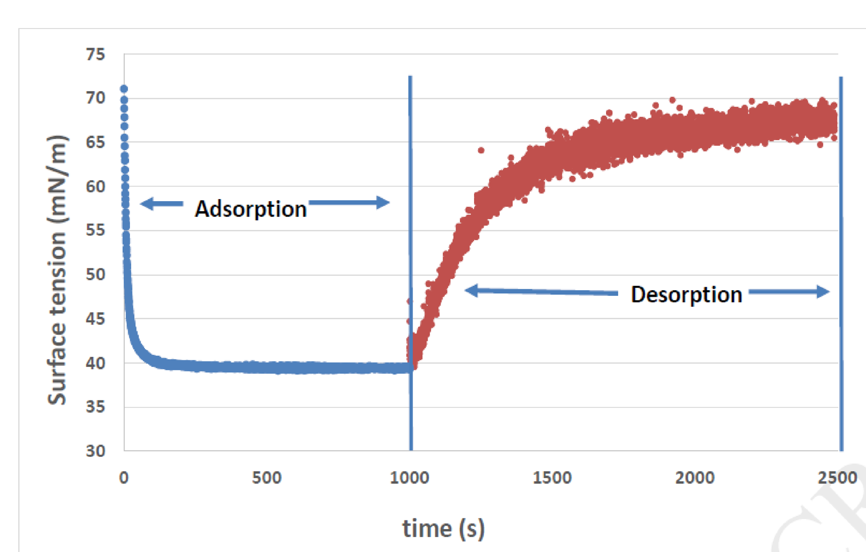
Results

Two drops tensiometer:

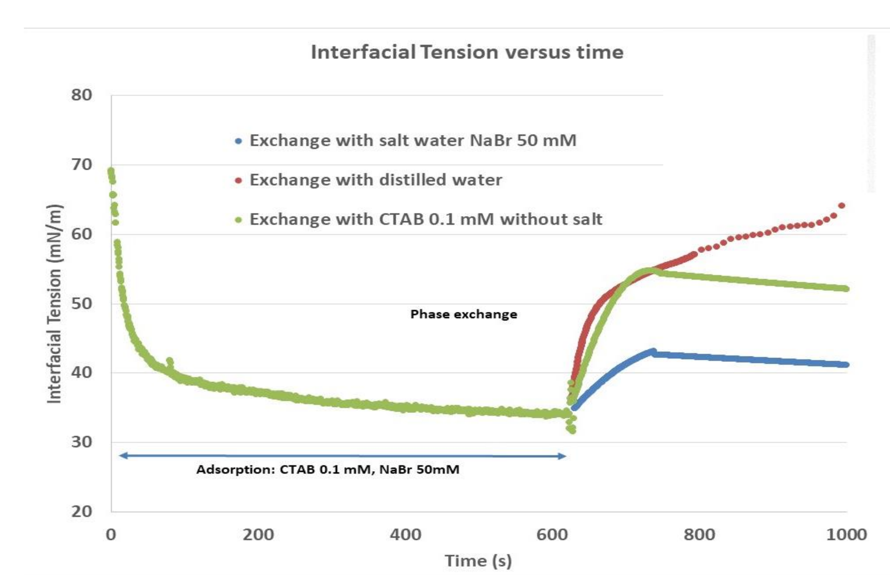


$\gamma(t)$ of the oil rich $C_{10}E_5$ (red) and air (black) same aqueous phase.
The second drop detects clearly the presence of $C_{10}E_5$ released in the bulk.

Liquid Bridge:



C12E5: Time variation of the surface tension of the surfactant solution (0.015 g/L) The first part of the curve shows the adsorption process. After 1000 s, the solution is replaced by distilled water with a flow rate of 0.2 µl/s. The figure shows that after another 1000 s, the surface tension is back to the pure water value, confirming that all the surfactant has been removed from the surface of the bridge.



CTAB: Below the CMC, in the presence and absence of added salt (NaBr).

After equilibration of the surface tension, the surfactant in brine is exchanged with a flow rate of 2µl/s with distilled water, brine or surfactant solution without salt. The surface tension rises steadily, as CTAB desorbs, when the rinsing phase is pure water.

Conclusion

The second drop allows to investigate how the surface active molecule can desorb from the interface and get diluted in the bulk. The two drops tensiometer highlights a mass transfer of C10E5 between the oil drop and the aqueous phase thanks to the second bubble.

Conclusion

The surface tension rises steadily, as CTAB desorbs, when the rinsing phase is pure water. However, rinsing with brine the evolution of the surface tension is weaker. CTAB does not desorb: evidence of a desorption barrier.

References:

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