Measuring instruments and Services for Interface Science

Science

A microfluidic Thin Film Pressure Balance to study free-standing liquid films

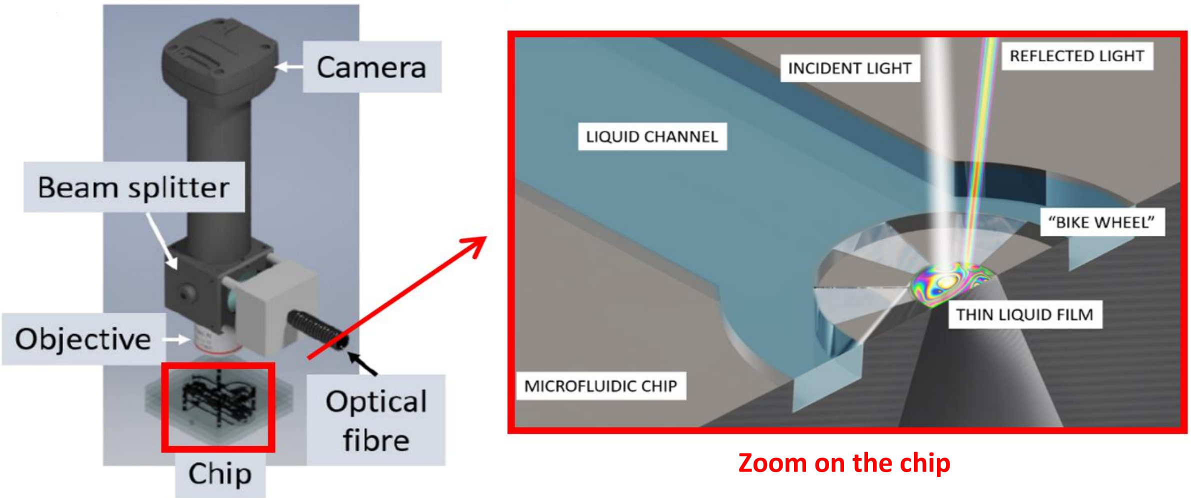

Figure 1- Setup of the microfluidic thin film pressure balance. Adapted from [4]

Free-standing liquid films are of growing interest due to their potential for a broad range of applications: they can be used as a model bio-membrane, as a "low-tech" option in gas separation processes [1] or as an artificial photosynthetic membrane to produce solar fuel [2]. They are also excellent model systems to investigate the properties of foam films [3] and confinement-driven effects in soft matter science.

At Teclis we share this growing enthusiasm for free-standing liquid films as we have built up strong expertise in interfacial phenomena and liquid foams. In this context, we participated in the development of a microfluidic thin film pressure balance (µTFPB) to study and characterize complex thin films in collaboration with the MIM team (Mechanics of Interfaces and Multiphase Systems) at the Institut Charles Sadron in Strasbourg [4].

Over the last decades, a good understanding of the thinning dynamics and the stability of free-standing liquid films has been achieved thanks to the extensive use of thin film pressure balances. These experiments were, however, limited to low-viscosity aqueous solutions. With the µTFPB, thin-film characterization can be extended to viscoelastic and complex fluids. In practice, the µTFPB is composed of three main parts: a fluid control system, an optical system and a microfluidic chip containing a microfluidic Radke-style bike wheel as shown in figure 1.

The smart design of the chip consists in several layers that can be easily dismantled and reassembled making the cleaning process easy for highly viscous and complex fluids. Moreover, the geometry of the tubing leading to the bike wheel can be changed and adjusted depending on the fluid of interest. The fluid control system, that allows to control both gas and liquid pressures independently, is also a key advantage of the µTFPB. This system provides a flexible control of the applied capillary pressure with a variable pressure offset unlike a classical thin film pressure balance. Thanks to these remarkable features, the drainage of a gelling polymer film has been observed for the first time using a µTFPB.

At Teclis, we are always happy to discuss interfacial phenomena, foams and soap films so we would love to hear your thoughts! Are you working with free-standing liquid films? What are the properties you are interested in?

We are looking forward to your comments.

Contact Us

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[1] Hadji, C., Dollet, B., Bodiguel, H., Drenckhan, W., Coasne, B., & Lorenceau, E. (2020). Impact of Fluorocarbon Gaseous Environments on the Permeability of Foam Films to Air. Langmuir, 36(44), 13236-13243.
[2] https://sofiaproject.eu/
[3] Karakashev, S. I., & Manev, E. D. (2015). Hydrodynamics of thin liquid films: Retrospective and perspectives. Advances in colloid and interface science, 222, 398-412.
[4] Andrieux, S., Muller, P., Kaushal, M., Vera, N. S. M., Bollache, R., Honorez, C., ... & Drenckhan, W. (2021). Microfluidic thin film pressure balance for the study of complex thin films. Lab on a Chip, 21(2), 412-420.

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Application Note

Dispersity : an indicator to classify the foam dissipation

Foams describe a large class of material made of gas and liquid. In some applications, foam stability is preferred, whereas quick foam dissipation is wanted for other applications. Therefore, it is crucial to know the characteristics of the foam in order to orient the formulation towards the desired behavior.

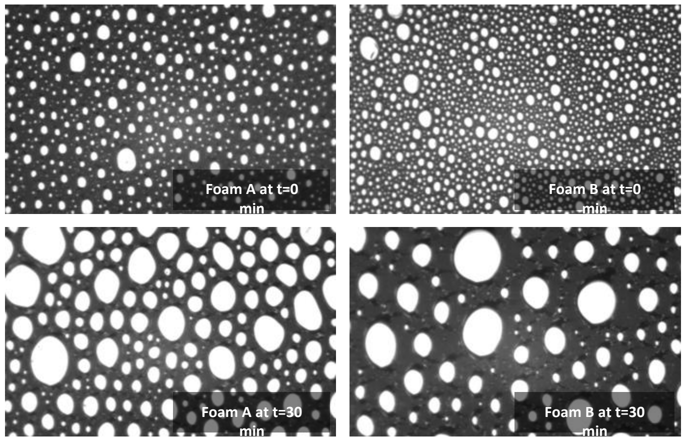
While aging, foam dissipates by three main mechanisms:

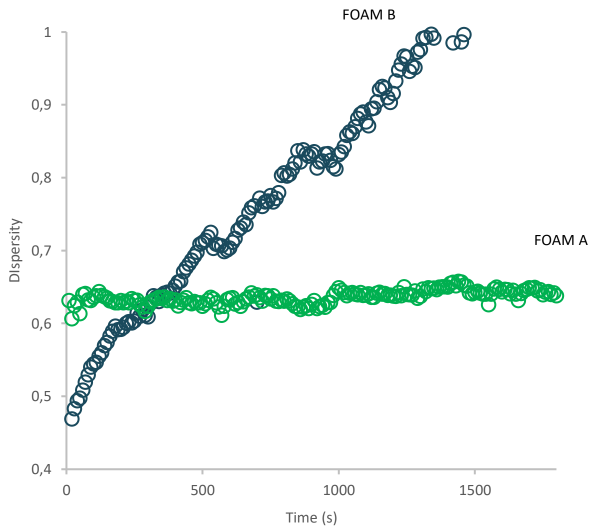
- Drainage operates due to gravity,
- Coalescence (bubble burst) occurs when the foam film becomes thin enough and two separated bubbles gather and form a larger bubble.
- Coarsening (or Oswald ripening) is driven by the difference of pressure between neighboring bubbles that leads the gas to move from smaller bubbles (higher gas pressure) to larger bubbles (lower gas pressure).

The aim of this note is to illustrate how the foam structure analysis can help to classify two kinds of foams that express two dissipation mechanisms.

Two foams A and B have been produced with the same foaming protocol. The foams' structure were studied with the FOAMSCAN™ Cell Size Analysis software. Assuming a monomodal bubble size distribution, the dispersity that is defined as the standard deviation over mean radius ratio, was calculated over time.

The pictures hereafter represent the foam before any image processing. The good contrast between the bubbles and the background allows to use the automatic segmentation process to count and analyze all the bubbles in every single image. The statistical parameter D (dispersion) was chosen in this work to illustrate the capacity of image analysis to bring information about changes in the structure of the foam. Dispersity D define as $D = \sqrt{\langle r^2 \rangle - \langle r \rangle^2} / \langle r \rangle$ was plotted over time for foam A and B. The dispersity of the bubble size distribution of foam A remains constant whereas it increases over time for the foam B. The difference in behavior is an indication of two different dissipation mechanisms. Foam B dissipates with coalescence events while coalescence plays a minor role in the dissipation of foam A. The mean bubble size composing the foam A increases over time probably by coarsening. [1], [2]





CONCLUSION

Two foams were produced, and their bubble size and distribution studied by images analysis. The two Foams structure evolution reveals a strong difference over time. Foam B dispersity increases over time, a signature of coalescence whereas foam A dispersity remains almost constant which strongly suggests a coarsening by Oswald ripening. The Dispersity parameter appears to be a powerful indicator to classify foams dissipation mechanisms.

[1] Boos, J.; Drenckhan, W.; Stubenrauch, C., On how surfactant depletion during foam generation influences foam properties. *Langmuir 2012, 28 (25), 9303-9310.*

[2] Boos, J.; Drenckhan, W.; Stubenrauch, C., Protocol for studying aqueous foams stabilized by surfactant mixtures. *Journal of Surfactants and Detergents* ***2013, 16 (1), 1-12.***