Application Note

Dispersity, an indicator to classify the foam dissipation

INTRODUCTION

Foams describe a large class of material made of gas and liquid. Depending on whether it is desired or not, it is crucial to know the characteristics of the foam in order to orient the formulation towards the desired behavior. In some applications, foam longevity is looked for, whereas a foam that dissipates quickly is wanted . The way the foam dissipates gives precious information and help to rank the different formulations. While aging, foam dissipates by three main mechanisms that are drainage, coalescence and coarsening. Drainage operates due to gravity, coalescence (bubble burst) occurs when the foam film becomes thin enough and coarsening is driven by the difference of pressure between neighboring bubbles. The aim of this work is to illustrate how image analysis of the foam structure can help to classify two kinds of foam that express two dissipation mechanisms.

METHODOLOGY

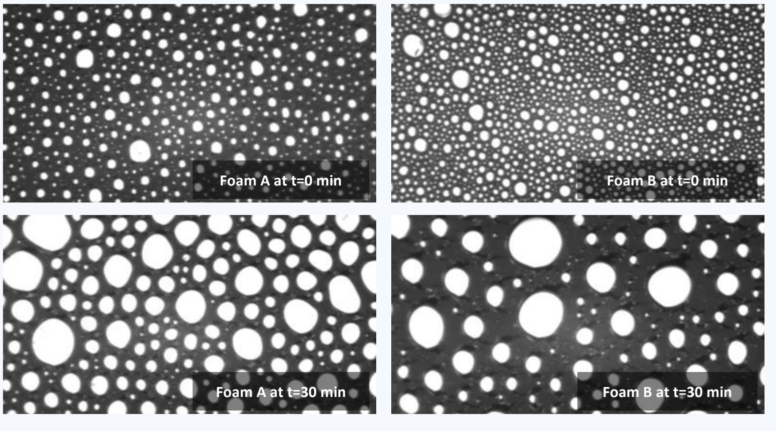
Two foams named A and B have been produced with the same foaming protocol. The foams structures were studied over time with the FOAMSCAN™ CSA (Cell Size Analysis software). Assuming a monomodal bubble size distribution, the dispersity that is defined as the standard deviation over mean radius ratio,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

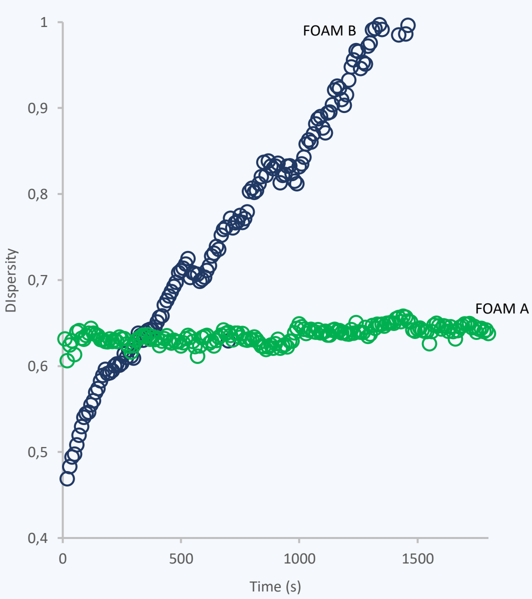
EXPERIMENTAL PROTOCOL

Foam A and Foam B were generated by mechanical stirring for 60 sec before being transferred into a glass vessel. Foam pictures were acquired every 10 sec over 1800 sec. Images were analyzed with the CSA software. From the available statistical data, standard deviation and mean radius of the bubble's population were extracted from each single image.

RESULTS

Foam structure was determined by image analysis. The pictures below 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]





Coarsening or Oswald ripening is driven by the pressure gradient between different sized bubbles and lead the gas to move from smaller bubbles (higher gas pressure) to larger bubbles (lower pressure).
Coalescence corresponds the process by which two separated bubbles gather and form a larger bubble.

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.

References
[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.***