Characterization of foam (Stability and Bubble size)

Introduction

One of the characteristic of a surfactant is its ability or not to generate foam. Surfactant are used in different application and some require foam (shampoo, detergent, etc) and other doesn't (pulps, paper industry, etc). The determination of the stability of the foam is important in order to get the right use property depending on the application.
The Turbiscan™ enables to measure the drainage of the foam and the coalescence of the air bubbles. In this note, the kinetics of destabilization was measured for different foam.

Reminder on the technique

Turbiscan® technology, based on Static Multiple Light Scattering, consists on sending a light source (880nm) on a sample and acquiring backscattered (BS) and transmitted (T) signal all over the sample height. By repeating this measurement over time at adapted frequency, the instrument enables to monitor physical stability.
The signal is directly linked to the particle concentration (φ) and size (d) according to the Mie theory knowing refractive index of continuous (n_f) and dispersed phase (n_p): $\boldsymbol{BS} = \boldsymbol{f}(\varphi, \boldsymbol{d}, \boldsymbol{n_p}, \boldsymbol{n_f})$

Method

Several surfactants have been tested after dissolution in demineralized water at various concentrations. 10 mL of these solutions were put in the measurement cells. The foam is created in-situ with a rotor-stator homogenizer (Ultraturrax®) for 5 minutes. The analysis is performed with the Turbiscan™ immediately after mixing.
The determination of the stability of the foam is done by using the scan mode (scanning the sample over the whole height) to follow the coalescence of the air bubbles over 30 minutes and the drainage of the liquid.

Results

Raw data

The stability of the foams is very easily visualized by looking at the variation of transmission and backscattering (Figure 1).
On the transmission variation graph (top), a clear layer is forming at the bottom of the sample due to the drainage of the liquid once the bubbles have burst after coalescence. On the other hand, we observed thanks to the delta backscattering graph the coalescence of the air bubbles over the duration of measurement.

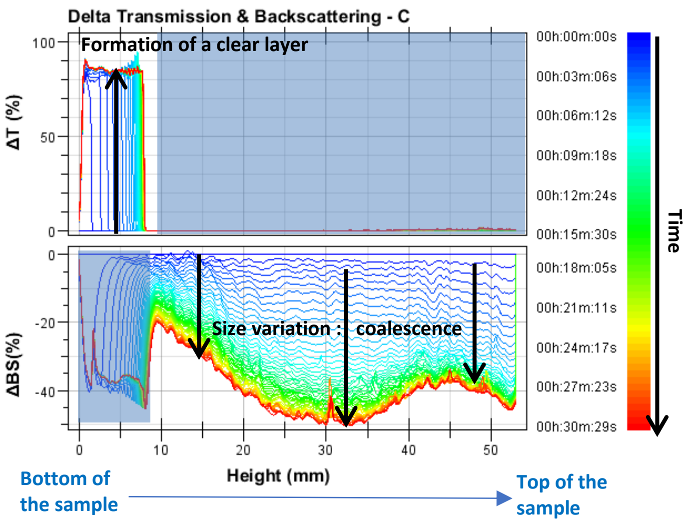

Figure 1: Transmission variation (top) and Backscattering variation (bottom) of sample C

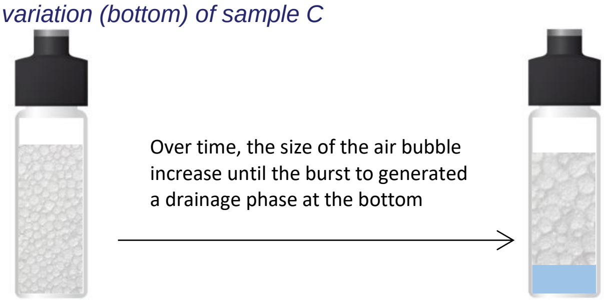

Figure 2: Representation of the destabilization

By measuring both, transmission and backscattering, variations, all the process of destabilization can be studied. The following parameters are computed:

- Thickness of the drainage phase
- Coalescence of air bubbles

Thickness of the drainage phase

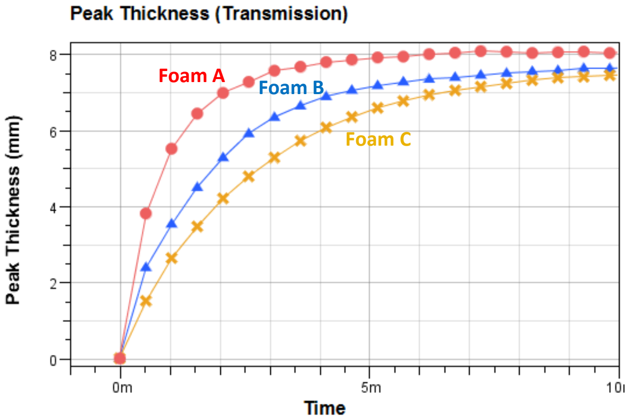

Figure 3: Peak thickness of the drainage layer at the bottom of the samples

Sample	Kinetics of destabilization (mm/hr)
A	192.52
B	101.93
C	94.15

Less Stable → More Stable

Table 1: Rate of foam breakdown

From Figure 3 and Table 1, we can rank the 3 samples by the kinetics of the foam breakdown into liquid. Formulation A is the less stable as the drainage phase is increasing faster.

Coalescence of air bubbles

Over time, the air bubbles tend to coalesce together and so their size increase until they reach the limit size were the bubble burst and so a liquid is released. The Turbiscan™ software allows the automatic computation of the mean diameter of the air bubbles directly from the level of backscattering on the foam phase. The graph in Figure 4 is generated.

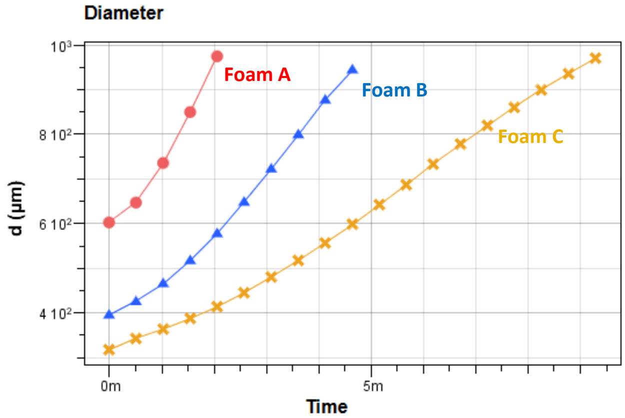

Figure 4: Air bubble size versus time

Sample	Bubbles size a t=0	Time before bubbles burst
A	601µm	2min4s
B	395µm	4min39s
C	317µm	9min18s

Table 2: Size of air bubbles at time=0 and time before they collapse

From Figure 4 and Table 2, we can conclude:

- For all foams, the diameter of the bubbles when they burst is the same, they burst at 960 +/- 15µm
- A time=0 the air bubble size is smaller for the foam C and so more time is needed to reach the limit size compare to sample A where the size is initially bigger.

CONCLUSION

In this application note, different foams were characterized using the Turbiscan in a short period of time. The kinetics of the drainage layer formation was measured as well as the process of coalescence. The graph below sums up the different computations

We can conclude than foam A is the less stable, the bubble size being bigger at time=0, they burst earlier and so the drainage phase is generated faster. Foam B and C have better and similar properties.