STUDY OF A QUICK BREAKING FOAM (STABILITY OF A HAIR FOAM)

INTRODUCTION

A foam is a substance that is formed by trapping pockets of gas in a liquid (or solid). Depending of the final application, they could be very unstable products with a shelf life that doesn't exceed few minutes. In the case of hair foams, the breaking of the product has to be quick to enable an easy application. Therefore the kinetics of breaking is a fundamental parameter for the formulator. However, this characterization is very difficult to perform due to the rapidity of the phenomenon.

Thanks to the Turbiscan™ technology and its ability to measure in "fixed position" mode, it is possible to study and characterize very unstable foam. In this application note two study were done, one to measure the effect of temperature of hair foam and one to evaluate the repeatability of the measurement for this application.

PRINCIPLE

Measurement with Turbiscan®

Turbiscan™ instrument, based on Static Multiple Light Scattering, consists in sending a light source (880 nm) on a sample and acquiring Backscattered (BS) and transmitted (T) signal. Combining both detectors (BS & T) enables to reach wider concentration range. The backward reflected light comes from multiple scattering as the photons scatter several times on different particles (or drop).

This signal intensity is directly linked to the diameter (d), according to the Mie theory:

$$d = f(BS, \varphi, n_p, n_f)$$

More information

METHOD

Commercial foams are analyzed using the Turbiscan technology with the "fixed position" mode. In this mode the intensity of the light in transmission and backscattering is measured at one specific height with measurement done every 0.5 second. For all the study the hair foams were characterized at 10 mm above the bottom of the cell.

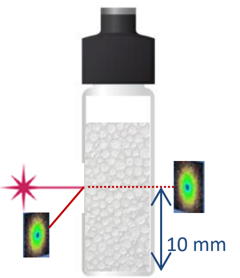

Figure 1: Schema « fixed position » mode

Two different studies were done:

- The effect of the temperature on the foam breakdown (4 different temperatures are evaluated, 30°C, 32°C, 35°C & 40°C which correspond to the temperature around body/hair temperature)
- The repeatability of measurement was evaluated. For the same foam, the measurement was repeated 4 times.

In order to compute the mean diameter of the air bubbles, the refractive index of the liquid was measure using a refractometer and the volume fraction was computed by scaling the samples and measuring the volume of foam (from the height of foam)

RESULTS

1- **Raw data**

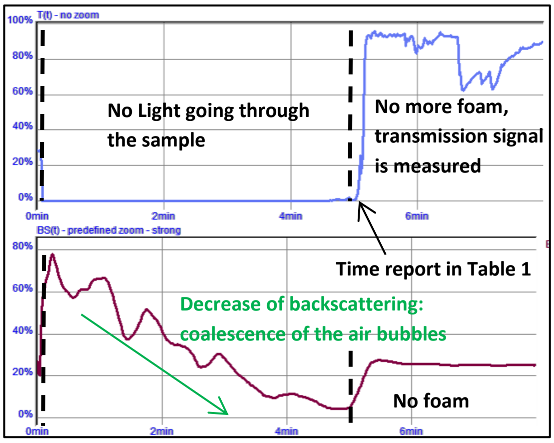

Figure 2: Transmission (top) and Backscattering (bottom) versus time for commercial foam at 30°C

Using the graph in Figure 1 we can observed:

- From the transmission graph, the light is not able to go through the sample during approximately the 5 first minutes and so, there is no transmission signal. Once the foam breakdown at this specific height the light is able to go through and we do have a signal.

- In the backscattering graph, the level of backscattering is decreasing over time due to the coalescence of the air bubble. By measuring this level, the diameter of the droplets can be computed.

2- Bubbles diameter over time

To compute the mean diameter of the air bubbles, the following parameter are recorded in the software

- Refractive index of the continuous phase np = 1.339 (value obtained by measuring the refractive index of the liquid phase)
- Refractive index of the dispersed phase nf = 1 (air)
- Volume fraction of the dispersed phase ϕ = 96 %

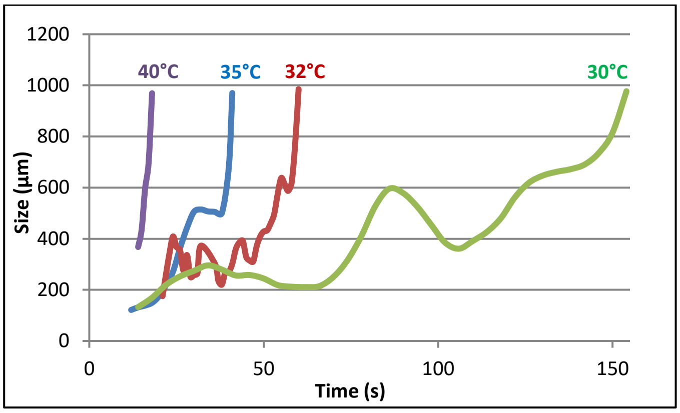

Figure 3: Bubbles size versus time

Thanks to the Figure 2, we can computed the time needed to have no foam at this specific height of measurement and thanks to Figure 3 we can measured the diameter of the droplets at time=0 as well as the kinetics of coalescence (slope of the curve). Table 1 shows the values for the different temperature of measurements for the same foam.

Temperature	Time before bubbles burst	Bubbles size a t=0	Kinetics of coalescence
30°C	5.1	132	4.40
32°C	3.47	175	10.19
35°C	1.91	160	23.31
40°C	0.93	367	146.44

Table 1: Characterization of the temperature effect

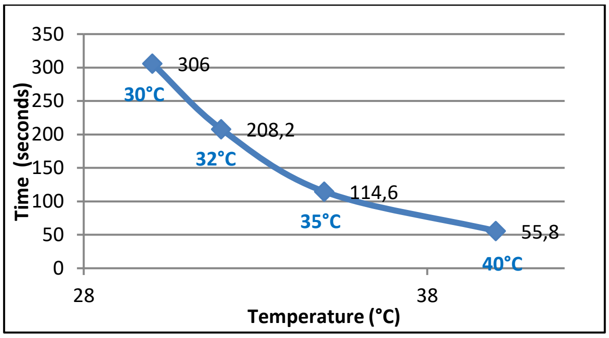

Figure 4: Time to before bubble burst versus temperature

The aim when hair foam is formulated is to generate the foam from the container (room temperature) but once applied in contact with the body temperature, the foam breakdown to a liquid. In this study we can see that the foam is pretty stable around room temperature and once the temperature gets higher the stability is strongly impact.

3- Repeatability

The same experiment has been repeated four times to check the reproducibility of the measurement. When dealing with foam, results are dependent of the time between the foam is generated and the time of the measurement is started. Moreover, it is difficult to generate homogeneous foam and even by visual observation we can observed different air bubble size. By using the multiple light scattering to measure the diameter of the air bubble an average of the bubbles is measure and so the repeatability is better. In Figure 4 the results obtained for 4 repeats of the same foam. The values obtained are in accordance with microscopic measurement.

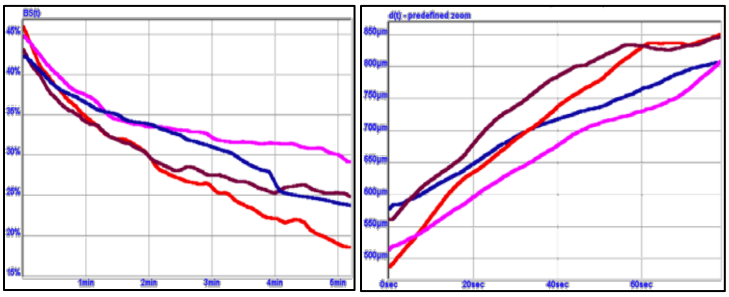

Figure 5: Variation of Backscattering (left) and air bubble size (right) over time (4 repeats)

For the same foam, the following variations are observed:

- Backscattering maximum deviation : 10.5 %
- Diameter maximum deviation: 115 µm (maximum incertitude on the mean value: ± 8%).

SUMMARY

Turbiscan technology enables analysis of foams even when their destabilization is very quick, thanks to the "fixed position" mode. This method is easy to implement and can be used as a formulation characterization (foam optimization) as well as for quality control (instantaneous verification of a state of the foam in term of bubbles concentration and bubbles diameter). The characterization of the foam is achieved with the bubbles mean size evolution determination.