Study of a slow breaking foam

Stability of a shaving foam

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Introduction

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 (like hair foam) or more stable product with a shelf life of hours or days. In the case of shaving foams, the stability of the foam has to maintain stable during the time of application at the body temperature (37°C). Therefore the kinetics of breaking is a fundamental parameter for the formulator. However, this characterization is very difficult to perform due to the fragility of the system.

Thanks to the Turbiscan™ technology and its ability to scan the sample over time, it is possible to study and characterize all type of foam. In this application note, two different shaving foams have been characterized in order to compare the stability of different formulation.

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):

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

Method

Commercial shaving foams were analyzed using the Turbiscan™ technology by scanning each sample from the bottom to the top at a frequency of one scan every 30 seconds for 3 hours. All the measurement were performed at 37°C to simulate the body temperature to evaluate the stability of the foam under real conditions. Due to the fragile structure of the foams they were generated inside the measurement cells to avoid any sampling.

At the end of the experiment, the refractive index of the resulting liquid is measured using a refractometer in order to be able to compute the mean diameter of the air bubbles over time with the Turbiscan™.

Results

1. Raw data

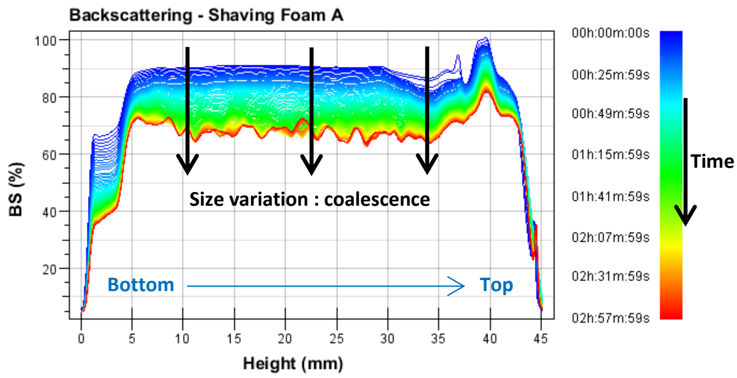

Figure 1: Backscattering variation for shaving foam A

From the graph in Figure 1, we can observe a global decrease of the intensity of backscattering over the time of analysis, this translates a size increase of the air bubbles over time. The air bubbles coalesce together to form bigger ones. In order to characterize the different shaving foams, the following parameters are computed:

- The global stability
- The kinetics of bubble coalescence

2. The global stability

It is possible to monitor the destabilization kinetics in the samples versus ageing time, thanks to the **T**urbiscan **S**tability **I**ndex (TSI). It sums all the variations detected in the sample (coalescence, clarification, liquid drainage, …). At a given ageing time, the higher the TSI, the worse the stability of the sample.

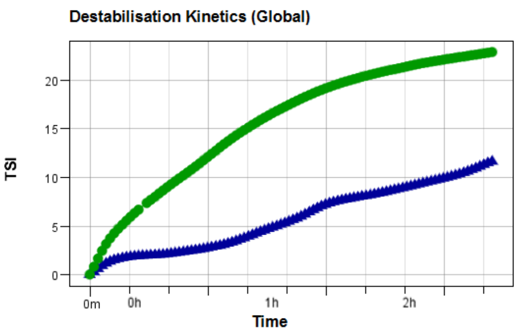

Figure 2: TSI values for all shaving foams

Sample	TSI (3 hours)
Shaving foam A	22.7
Shaving foam B	11.2

Table 1: TSI values after 3 hours of measurements

Thanks to Figure 2 & Table 1, we can identify that less change happen in the shaving foam B (coalescence of the air bubbles) and so this sample is considered more stable.

3. Kinetics of bubble coalescence

Over time, the air bubbles tend to coalesce so their size increases until they reach a maximum then the bubbles burst and 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 using the following parameters:

- 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 %

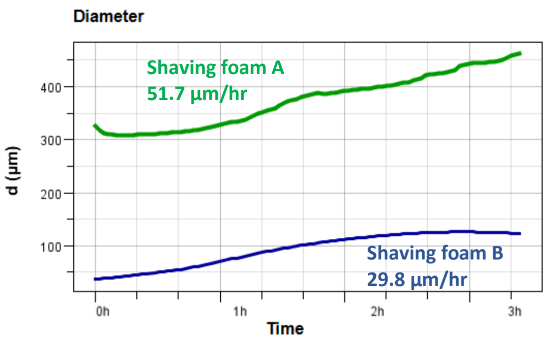

Figure 3: Air bubbles size versus time

Sample	Bubbles size at t=0 (µm)	Kinetics of coalescence (µm/hr)
A	307	51.7
B	35.5	29.8

Table 2: Characterization of the different shaving foams

According to the Figure 3 and table 2 we can conclude:

- The air bubbles size of the shaving foam B is initially 10 times smaller than for the shaving foam A.
- The kinetics of the coalescence of the air bubbles is computed by measuring the slope of the Figure 3. The air bubbles on the shaving foam B coalesce at the slower rate compared to the shaving foam A.

The optical microscopy requires many analyses to obtain accurate data. When the foam is placed between slide and cover glass the bubbles can interact and break differently from when they are "naturally" conditioned. We assume that the bigger bubbles are broken while sampling the foam.
Nevertheless, this technique is commonly used in the industry and provides information on the bubbles shape and can be used to determine the bubbles mean diameter (using many samples for the results to be statistically valid).
The shaving foams in this study were analysed using microscopy techniques, the mean bubble size is determined after 10 experiments and is equal to about 20 µm (shaving foam B)
This value can be compared to the value obtained with the (about 35 µm). The Turbiscan™value is higher than with the microscope which could be explained by the fact that we are not breaking the biggest bubbles during sampling. Moreover, the Turbiscan™ technology follows the size evolution of the bubbles during the foam coalescence

CONCLUSION

In this application note, 2 different shaving foams have been analyzed and characterized using the Turbiscan technology and that within only 3 hours of measurement. Different parameters where computed including the automatic TSI computation and the mean diameter of the air bubbles over time. It was shown from all the parameters that shaving foam B have better stability properties due to a smaller air bubbles size when the foam is generated. The following graph sum up all the computation done during this study.