Application Report

Foamability and foam stability

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Dynamic Foam Analyzer – DFA100

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Investigating the foam-inhibiting effect of antifoaming agents in printing lacquers

Abstract

The formulations of aqueous printing inks and lacquers normally include surfactants as wetting and dispersing agents. An unwanted side-effect of adding surfactants is the tendency to foam formation. Foaming inks and lacquers cause numerous quality problems: They make processing and quality control more difficult, and they cause faults in the print image and reduce adhesion on the medium. This is why antifoaming agents are added to aqueous printing inks and lacquers to minimize foam formation.

In the foam analysis of printing inks and lacquers, attention is paid to both the amount of foam generated and to its stability. With the Dynamic Foam Analyzer – DFA100 from KRÜSS the foamability and foam stability can be determined in the course of a single measurement. In the framework of this application report the effect of two silicone-based antifoaming agents in printing lacquers is compared at the same active agent concentration. For one of these antifoaming agents the effects were also investigated at a concentration reduced by 25%.

Experimental part

Studied samples

An ink manufacturer wanted to use the DFA100 to test a new antifoaming agent formulation as a component of a printing lacquer and compare it with that previously used. The same printing lacquer was always studied, the antifoaming agent with the previously used formulation (Sample A) and a new formulation B added to it. For Sample B1 an active agent concentration comparable to Sample A was used. Sample B2 contained the antifoaming agent in a concentration reduced by 25%, in order to reduce the cost-intensive agent addition. A repeat measurement with a new batch was carried out for all samples.

Sample	***Antifoaming agent***
A	Old formulation
B1	New formulation
B2	New formulation, concentration reduced by 25%

Table 1: Studied samples

Setup and measuring procedure

50 mL of the particular sample was placed in the sample vessel of the DFA100 (Fig.1a).

Air was passed through the sample via the porous base (G2; pore size 40 - 100 µm) of the sample vessel at a constant volume flow (Q = 0.7 L/min) for 12 s (Fig. 1b). The measurements were compared under these foam generation conditions.

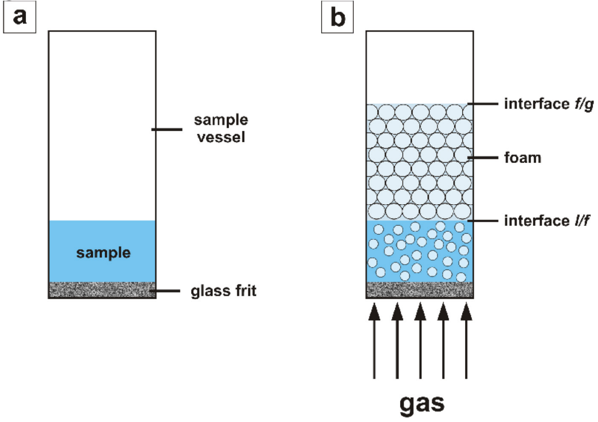

Fig. 1: Foam generation by airflow with the DFA100

Alternatively, with the DFA100 foam can be generated with a stirrer. This method was not used as differences in the decay properties are normally clearly visible with the airflow method.

During foam generation and subsequent foam decay the total height h (consisting of foam and liquid columns) was followed *in situ* by measuring the light transmission as a function of time (Fig. 2).

In the DFA100 height measurement is carried out by using an LED panel and a photodetector between which the column is located. The phase boundaries foam / gas and (for transparent liquids) foam / liquid are detected by using the difference in intensity (Fig. 2).

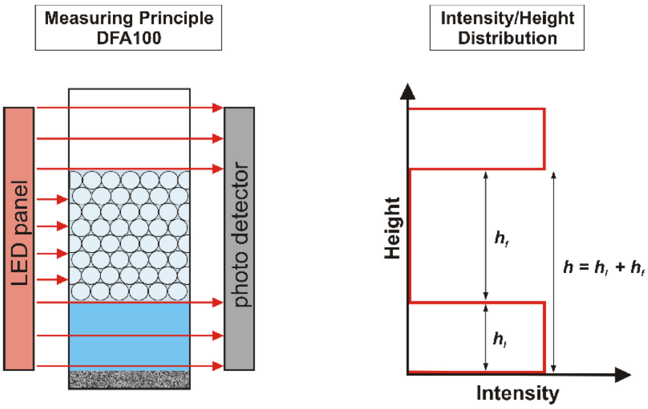

Fig. 2: Height detection with DFA100 for a non-transparent liquid

During foam generation the total height h increases continuously. At the end of the foam generation time ($t = t_{End}$) h has a maximum value h_{max}. As time continues ($t > t_{End}$) the foam column decays.

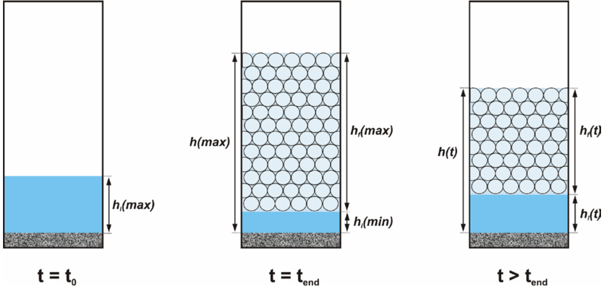

Fig. 3: Measurement sequence

As the samples were light-impermeable and the transition between the liquid phase and the foam could not be detected, the foam behavior was studied by following the total height h (Fig. 2).

Results

The following illustration (Fig. 4) shows the curves of the total height as a function of time for the six foaming tests (Sample A, B1 and B2 each with a repeat measurement). As a result of the good reproducibility (Δ_{max}=1.2 mm; Tab. 2 and Fig. 4) further measurements were dispensed with.

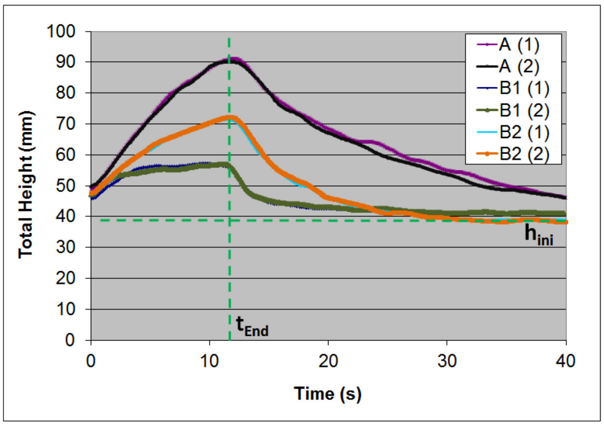

Fig. 4: Foam generation and decay curves

The curves increase until the airflow is switched off. The switch-off time t_{End} is shown by a vertical line. Foam decay begins after this line.

The horizontal line describes the initial height h_{ini}, i.e. the height of the liquid surface before foam generation.

Between Samples A and B a clear difference in foaming behavior can be recognized (Tab. 2) at a comparable antifoaming agent concentration (Sample B1). Starting from an initial height h_{ini} of 40 mm, the total height for Sample B1 increased to 57 mm, for Sample A the height was 90 mm; this corresponds to the 3-fold amount of foam produced. Even at a 25% lower concentration, antifoaming agent B (Sample B2) showed an increase in the total height to only about 72 mm.

Discussion

Formulation B is both more effective with regard to foam formation and more efficient with respect to the decay of the formed foam. Even with the active agent concentration reduced by 25%, B2 appears clearly more advantageous than A but, as expected, poorer than the higher initial concentration of the active agent B1.

Antifoaming agents usually act not only as foam inhibitors; they also destabilize the foam that has been formed. This effect can be evaluated by using the decay curve and calculated parameters such as, for example, the decay half-life. The latter describes the time in which the foam height (referred to the initial height h_{ini}) is reduced to the half of its maximum value.

Sample (measured)	***Max. total height h_{max}***	***Decay half-life***
A (1)	91.2 mm	9.6 s
A (2)	90.0 mm	9.4 s
B1 (1)	57.2 mm	1.2 s
B1 (2)	57.0 mm	1.2 s
B2 (1)	71.4 mm	3.8 s
B2 (2)	72.3 mm	3.4 s

Table 2: Results for the foamability and foam stability of the samples

This also shows the advantages of the new formulation B: Whereas the foam height (measured from the initial height before foam generation) for Sample A had diminished by half after an average of 9.5 s (half-life value), Sample B1 only required 1.2 s at a comparable concentration (Tab. 2).

The alteration in the concentration for formulation B (Sample B2) also influenced the foam stability: Reducing the amount by 25% increased the half-life value 3-fold (Tab. 2). Whether the use of the formulation with the reduced concentration for B is advantageous depends on whether the maximum height is crucial, or the amount of foam remaining after a certain time. For Samples B1 and B2 the remaining amount of foam has returned to the same value near the initial height after about 22 s (Fig.4). If this decay speed is quick enough for the application then a reduction in the concentration may be beneficial for cost reasons.

Summary

Foam generation and decay experiments on samples of a printing lacquer, to which two different antifoaming agents A and B had been added, were carried out using the DFA100 in a single run. By using the total height at the end of the foam generation process it was possible to clearly demonstrate differences in the effectiveness of the two formulations. The use of the superior formulation B, even at a concentration reduced by 25% in comparison to A, resulted in a clearly lower level of foam formation of the sample.

In the samples the reduction in foam formation was associated with a quicker decay of the foam and therefore reduced foam stability. This could be shown by the decay half-life values.

The recommended concentration for formulation B depends on whether the maximum foam height or the height after a particular decay time is significant for the particular application.

Repeat measurements for each sample show a very good reproducibility of the foam generation and decay curves, so that the differences between the samples could clearly be traced to the different antifoaming formulations and concentrations.

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