The influence of experiment settings on foaming capacity

INTRODUCTION

The important parameters that are needed to be considered if you want to characterize the properties of aqueous foams are well described in the scientific literature [1]

However, the aptitude of a liquid to form foam is closely linked to the method used to produce the foam. TECLIS foam analyzers can be used to generate the foam :

- Either by bubbling a gas into a liquid through a glass frit,
- Or by mechanical agitation of a liquid

Each time, the choice of each experiment settings, such as the volume of liquid, the stirring speed rate, the glass frits' porosity, the gas flow rate, the temperature... can influence the results of the measurement.

Those settings are most often estimated thanks to users' experience, in order to replicate an industrial process, or simply by empiricism...

The purpose of this document is to illustrate, with an example, how experiment settings can influence the results of the foaming capacity, while using TECLIS foam analyzers.

CASE STUDY

A campaign of measurements was carried out at TECLIS laboratory using:

- A Solution of demineralised water +2 g/L of Pluronic® F-127 + 0.1 M NaCl
- Using 2 foam generation modes.
- 3 measurements per sample to ensure repeatability

FOAMSCAN™ Foam generation by gas sparging	**FOAMSPIN™** Foam generation by stirring
• Measurement of the foaming time required to reach a target foam 200 mL (Protocole 2) • Measurement of the final liquid volume • Experimental conditions: - Wetted glass frit - Room T° • Assessed settings: - Porosity of the glass frit: P00 (250-500 µm), P2 (40-100 µm), P4 (10-16 µm) - Initial liquid volume 30 mL and 60 mL.	• Measurement of the foaming time required to reach a target foam volume of 220 mL (Protocol 2) • Measurement of the final liquid volume • Experimental conditions - Wetted stirring chamber - Room T° • Assessed settings: - Stirring speed rate: 1000 / 1500 / 2000 / 3000 / 5000 / 6000 rpm. - Initial liquid volume 90 / 120 / 150 / 180 mL.

INFLUENCE OF EXPERIMENT SETTINGS ON THE FOAMING CAPACITY OF A FOAM GENERATED BY SPARGING A GAS

- Gas Flow rate has a strong impact on foaming time but seems to less affect the quantity of liquid consumed by the foam (Fig1).
- The porosity of the glass frit has a strong impact on the foaming time. The smallest pore diameter, the longest it takes to reach the foam volume (Fig1).

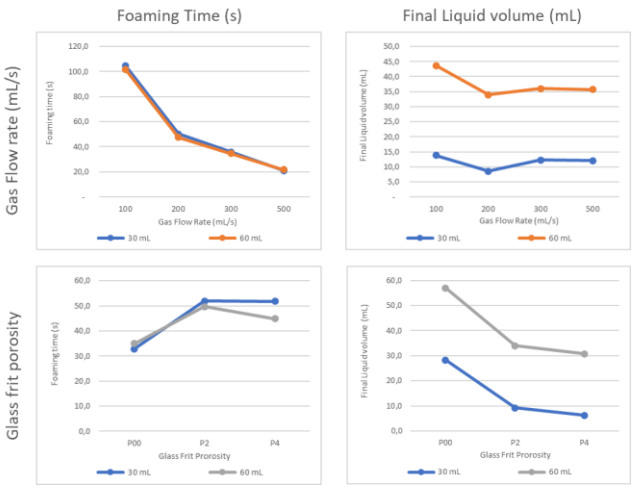

Fig1 - Foam generation by gas sparging – comparative data

- The porosity of the glass frit also influences the quantity of liquid consumed to form the foam. A small porosity will lead to a wetter foam (more liquid consumed) than a large porosity (Fig1).
- The initial liquid volume does not seem to influence the results (Fig1).
- The foaming time and Final liquid volume are not influenced whether you are using a dry or wet glass frit (Fig2). However, in order to avoid repeatability issues, we recommend to use wetted glass frits for all measurements.

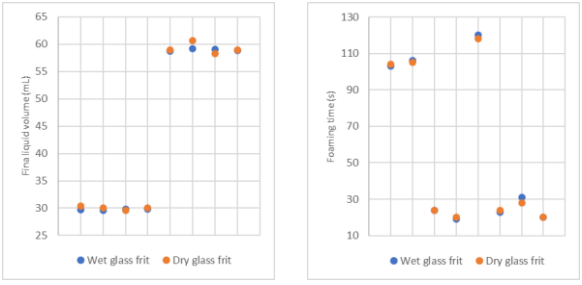

Fig2 – Influence of using wet or dry Glass frits

INFLUENCE OF EXPERIMENT SETTINGS ON THE FOAMING CAPACITY OF A FOAM GENERATED BY STIRRING

- Stirring speed has a strong impact on both foaming time and quantity of liquid consumed to generate the foam (Fig3).
- At low-speed rate (below 1000 rpm) the foaming time is significantly related to the initial liquid volume (Fig3).
- At high-speed rate (>= 2000 rpm) the lower initial liquid volume 120mL is totally consumed by the foam (Fig3).
- Obviously, the speed rate is strongly related to the viscosity of the solution. Here with an aqueous solution optimum speed rate is in between 1000 and 3000 rpm. For more viscous solution higher speed rate can be applied (Fig3).

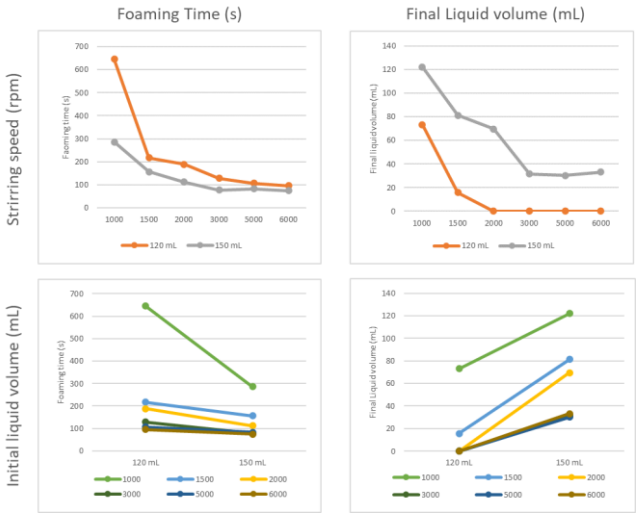

Fig3 - Foam generation by mechanical stirring – comparative data

- Using a dry or a wet stirring chamber may influence the results of the measurement (Fig4). After automatic cleaning, a small amount of liquid (+/- 10 mL) can remain in the channels of the stirring chamber. Therefore, we recommend to perform all measurements in the same conditions either using a wet chamber or a dry chamber.

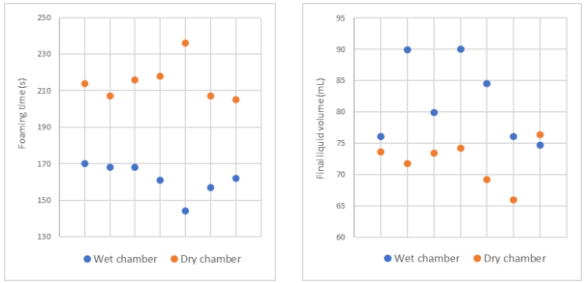

Fig4 – Influence of using wet or dry stirring chamber

- Although the capacity of the stirring chamber is 90-180 mL, it is always better avoiding working at the minimal and maximal volume capacity (Fig5):
  - Maximal initial liquid volume (180 mL)→ risk of distorting the conductivity and false the liquid volume measurement
  - Minimal initial liquid volume (90 mL) → risk of adding air in the foam because there is no liquid anymore.

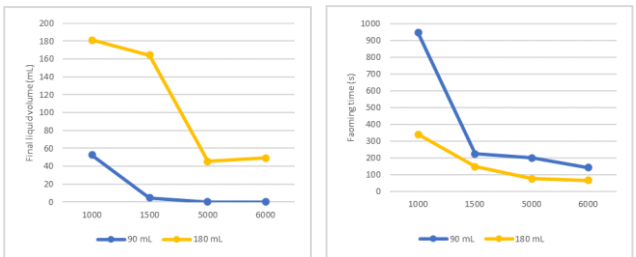

Fig5 - Foam generation by stirring – 90 mL / 180 mL

The optimum settings for the F127 solution are:

- Initial liquid volume between 120 mL and 150 mL
- Stirring speed : from 1000 rpm to 3000 rpm

CONCLUSION

Trough this example, we show that the aptitude of a liquid to form a foam is always influenced by the experiment settings chosen. However, some settings impact the results more than others.

For Foam generated by sparging a gas, the combination gas Flow rate x glass frit porosity is impactful whereas the initial volume of liquid is not.

For Foam generated by stirring, the combination initial liquid volume x stirring speed must be carefully chosen.

References

[1] Protocol for Studying Aqueous Foams Stabilized by Surfactant Mixtures - Julia Boos, Wiebke Drenckhan, Cosima Stubenrauch - J Surfact Deterg (2013) 16:1–12 DOI 10.1007/s11743-012-1416-2