The effect of fermentation defoaming agents on Tangential-Flow Filtration performance

1 INTRODUCTION

Tangential flow filtration (TFF), also known as cross flow filtration (CFF), comprises a rising technology in the last decades for the dewatering, isolation, and concentration of products of interest (e.g. biomolecules, metabolites and cells) from bioprocesses. Tangential Flow fitlration consists on the passage of the product feed in parallel to the surface of the filtering element/membrane [1]. The most bioprocesses use surface-active agents to reduce the foam formation, widely known as antifoams, defoamers and defoaming agents among others. These defoaming agents can be of different kinds depending on what they are made of, being silicone antifoams, oil antifoams, and glycol antifoams common examples of them. Usually, the main criteria for the selection of the right antifoam are effectiveness in low amount, biocompatibility and price. Nevertheless, the criteria selection also must take into account the downstream process type to be used, in order to avoid fouling problems and the formation of sub-layers of particles. This would otherwise reduce the filtration yields, having a detrimental impact on the flux (i.e. operation times), the operating costs of production, the cleaning, the maintenance and the optimal design of the filtration unit [2].

2 OBJECTIVE

To characterize the effect of different defoaming agents and pre-treatments of the product broth in microfiltration process, by comparing the filtration yields obtained with the different antifoams (silicone and non-silicone based, mainly) and the presence or absence of pre-treatment (500 μm pre-filtration vs. centrifugation).

3 MATERIALS AND METHODS

a. Tangential-Flow Filtration

A Tangential Flow Filtration test with fermentation broth of bacteria was carried out in a Bionet's M1 labscale tangential flow filtration system, whose main characteristics are:

- It can work with both ceramic and hollow fiber membranes interchangeably.
- It has feed and retentate pressure measurements and the transmembrane pressure adjustment can be done manually.
- It has a jacketed tank that allows for temperature control (Figure 1).

The chosen membrane was of ceramic type, of the following characteristics:

- 7 channels of an internal diameter of 2 mm.
- A total filtration membrane surface of 0.0132 m^2.
- Material: TiO2 (support) + ZrO2 (active surface).
- A pore size of 0.45 μm.

Figure 1. BIONET's M1 labscale tangential flow filtration system

b. Samples

The samples were classified as with a silicone antifoam both with and without pre-treatment, and with non-silicone antifoams (Fig. 2).

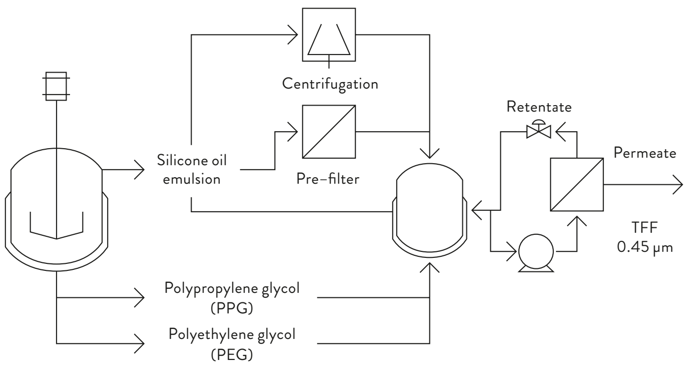

Figure 2. Scheme of the setup of the TFF trials with different AF

c. Flux and Transmembrane Pressure (TMP)

The permeate flux was calculated as the result of the volume flowing through the membrane per unit area per time:

$$Jp\ [L/(h \cdot m^2)] = \frac{Qperm}{Amembrane}$$

The transmembrane pressure (TMP) was calculated as the difference in pressure between two sides of the membrane, as an indicator of the force needed to pass the broth through the ceramic membrane filter.

$$TMP\ [barg] = \frac{P1(Feed) + P2(Retentate)}{2} - P3(Permeate)$$

d. Permeability of membranes

The permeability of the membrane was determined before the execution of each test in order to evaluate the membrane recovery after each trial. The permeability was determined according to the next expression:

$$Permeability\ [L/(h \cdot m^2 \cdot bar)] = \frac{Qperm \cdot Kt}{TMP \cdot Amemb}$$

The transmembrane pressure (TMP) was calculated as the difference in pressure between two sides of the membrane, as an indicator of the force needed to pass the broth through the ceramic membrane filter.

4 RESULTS

The conditions selected to carry out the microfiltration process on all samples were a crossflow velocity of 5 m/s, according to the pump characteristic curve, a constant TMP of 1.3±0.1 barg, reached by controlling the valve of the retentate line that corresponds to the P2 (retentate pressure) and a constant temperature of 25±0.1°C. Figure 3 shows the effect of crossflow velocity on flux (L/h/m^2), obtained for each defoaming agent and pre-treatment under study, and Figure 4 shows the average flux (over time):

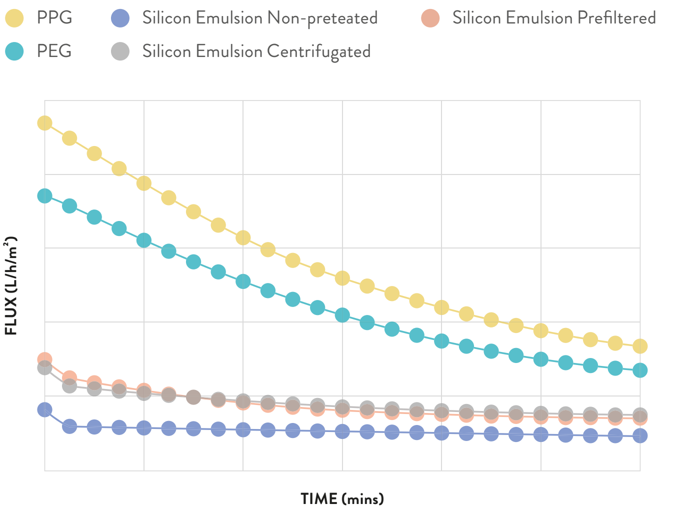

Figure 3. Evolution of permeate flux during the TFF of bacteria broths containing different defoaming agents and with or without pre-treatment.

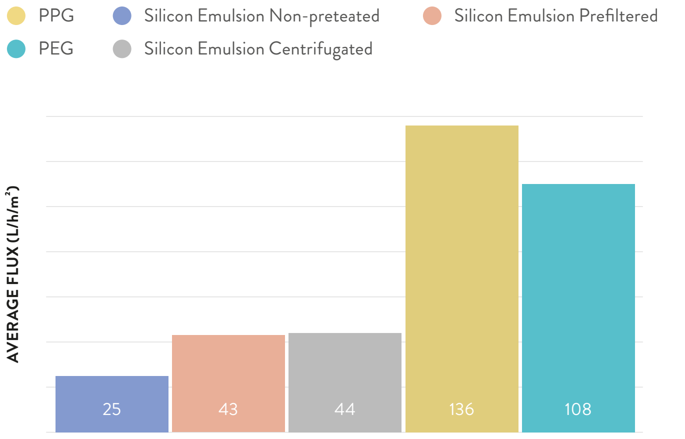

Figure 4. Comparison of the average flux obtained for each defoaming agent over time.

CONCLUSIONS

The selection of the right defoaming agent has a direct impact on the filtration operation costs, time and optimal technology design.

The results of this work demonstrate differences in the permeate fluxes (i.e. tangential flow filtration performance) between the fermentation broths containing silicone antifoams and those subject to non-silicone antifoams. The presence of pre-treatment in the broth containing silicone antifoams improves the flux in a 70-72% in comparison to when no pre-treatment before Tangential Flow Filtration has taken place. However, the use of a non-silicone antifoam instead improves the flux much more significantly, between 325-432%.

The efficiency of cleaning and membrane recovery is also critical to evaluate the feasibility of the defoaming agent. This is due to the reusable nature of membranes due to the high prices of disposable membranes, especially relevant for those processes in which the target product is a commodity or non-high added value product. In this study, the membranes of all experiments recovered at least 90% of the initial permeability.

REFERENCES

[1] Henry, J. D. (2018). Cross flow filtration. In Recent developments in separation science (pp. 205-225). CRC Press.

[2] Kroner, K. H., Hummel, W., Völkel, J., & Kula, M. R. (1986). Effects of antifoams on cross-flow filtration of microbial suspensions. In Membranes and membrane processes (pp. 223-232). Springer, Boston, MA.

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