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Membrane filtration for the recovery of lipids from microalgae extracts

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Introduction

Biorefinery of microalgae offers opportunities to substitute biomolecules (lipids, proteins, polysaccharides, pigments etc.) to traditional raw material in various industry sectors such as food and feed, cosmetics, pharmacy, energy or green chemistry. For large-scale production, wet processing of biomass has been proposed in order to save energy (by lowering the dewatering rate) and to be sparing with thermolabile molecules. Membrane filtration is well suited for such purposes and is therefore a promising process for the downstream processing. In this work we focus on the recovery of lipids from aqueous extracts of microalgae. After the culture of two strains, *Nannochloropsis gaditana* and *Parachlorella Kessleri*, in starving conditions to enhance their lipid production, the micro-organisms were ground and the resulting mixture were centrifuged to extract aqueous fractions containing a large quantity of dispersed lipids. This aqueous extract was then characterized and a model mixture was formulated to mimic the lipid profile and dispersion. As the control of the culture starvation and lipid production is difficult, this model solution facilitated the comparison of the filtration processes. Then model mixtures and real ones were filtrated on a plane cross flow filtration pilot and in a dynamic filtration pilot. The objective of the work was to compare the performances of the two systems and to assess the potential of membrane filtration for the separation of lipids from aqueous microalgae extracts. In real extracts, hydrophilic compounds (proteins and polysaccharides) were also present. Therefore, their concentration was also measured to evaluate the membrane selectivity between lipids and hydrophilic compounds.

Material and Methods

The microalgae extracts were produced and analysed according to the protocol described previously by E. Clavijo et al. (Clavijo et al., 2016). The model mixture was then formulated as an emulsion containing two vegetable oils, phospholipids and glycolipids in the same proportions as in the aqueous extract, with similar total fatty acids content.

Two filtration systems were used: a crossflow filtration module (CFM) and a dynamic filtration module (DFM) equipped with a polyacrylonitrile membrane (500 kDa) previously selected (Clavijo et al., 2017; Villafaña López, Clavijo, Liu, Couallier, & Frappart, 2017). The filtration performances (selectivity, flux, fouling, coalescence of the lipid droplets and cleanability) were evaluated using different analytical methods: gravimetry, gas chromatography to quantify the lipid analysis, BCA method for proteins and Dubois method for polysaccharides. The particle size distribution was measured by microscopy and laser granulometry to evaluate the coalescence.

Results and Discussion

The polyacrylonitrile membrane showed low fouling properties with the model mixture. Coalescence of oils droplets seems to appear beyond 10% (w/w) of oil in the retentate, especially during dynamic filtration. These filtration conditions improved water permeation, and, by delaying fouling phenomena, allowed to work at higher critical transmembrane pressure (TMP) (figure 1). The same conditions of dynamic filtration were tested on real extracts and promising results were obtained: the lipids were retained and a fraction of proteins permeated through the membrane. The figure 2 presents the real microalgae extract before and after filtration.

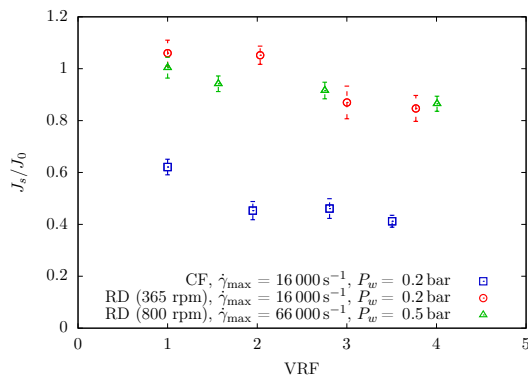


Figure 1: Comparison of the normalized flux versus the volume reduction factor (VRF) with the model solution, for cross-flow (CF) and rotating disc (RD) filtrations.

Conclusions

These results confirm the pertinence of a filtration step into the downstream processing for the biorefining of microalgae and more specifically for the recovery of lipids. The optimization of the selectivity between lipids and proteins will need further studies.

References

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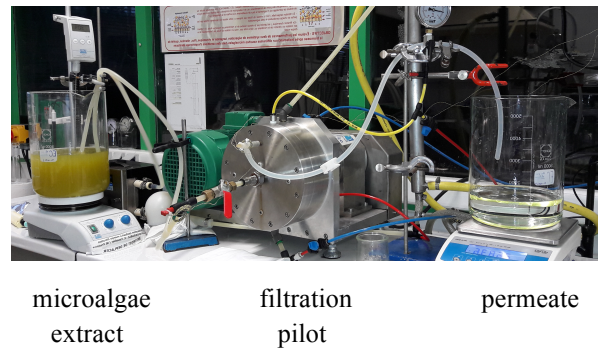


Figure 2: dynamic filtration of real microalgae extracts (supernatant of ground *Nannochloropsis gaditana* cultivated in starving conditions)