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Recovery of lipids from microalgae extracts by membrane processes: Comparison of cross-flow and shear-enhanced filtration performances.

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Highlights

- Membrane filtration allows the concentration of lipids from disrupted microalgae.
- The rotating disk filtration with a PAN membrane offers the best performances.
- An optimized coupling between cell disruption and filtration will enhance the biorefining.

1. Introduction

The biorefinery of renewable resources like microalgae offers great opportunities to substitute biomolecules to traditional raw materials in various industry sectors. Such strategies necessitate innovative choices of soft and energy-efficient processes to guarantee the integrity of fragile molecules and develop eco-friendly production. For large-scale production (food, energy or green chemistry), a wet processing of biomass has been proposed, that avoids expensive drying steps and reduces solvent use. However the energetically efficient extraction of biomolecules at low cost and industrial scale is not yet mature. Biomass wet treatment includes 1- the harvesting, 2- the cell disruption step to release the valuable biochemical compounds in the aqueous phase, 3- the fractionation step (extraction, concentration and purification). The integration of membrane processes into the microalgae downstream processing concerns the harvesting and the concentration of microalgae, but membrane filtration is also a promising clean separation process for the fractionation step.

In this work we focused on the recovery of lipids from *Parachlorella kessleri*, cultivated in starving conditions to enhance their lipid production. Clavijo et al. [1] demonstrated that the supernatant after bead milling and centrifugation of *Parachlorella kessleri* contains an important part of emulsified lipids in aqueous phase (until 50 % of total lipids).According to literature, the lipid recovery from microalgae is mostly performed with supercritical CO_2 on dried matter or solvent extraction. In this study the recovery of lipids from aqueous extracts was performed by membrane processes.

2. Methods

A model solution was formulated, based on the analysis of ground *Parachlorella kessleri* [1]. Then the performances (retention, flux, fouling, cleanability) of polyacrylonitrile (PAN), polyethersulfone (PES) and polyvinylidene fluoride (PVDF) membranes to concentrate lipids from *Parachlorella kessleri* aqueous extracts were evaluated, using the model solution. The most appropriate material and conditions (TMP) were then selected and validated on real microalgae fractions. Two filtration modes were compared ~~allowing~~ : the crossflow filtration in a plane module (CF) and the shear-enhanced filtration in a rotating disk module (RD).

3. Results and discussion

The PAN 500kDa membrane presented the best performances (flux, lipid retention and cleanability) in crossflow and rotating disk filtrations. It was selected to test the filtration of real aqueous extracts from *Parachlorella kessleri*. The performances of the PAN membrane in CF module with the real products were similar to the ones with the model solution despite the composition differences. The lipids were totally retained whereas some of the hydrophilic compounds (polysaccharides and proteins depending on the conditions) could permeate. The RD filtration allowed reducing the membrane fouling and using a higher transmembrane pressure, thus it led to higher fluxes. In the case of real aqueous extracts RD filtration, the water permeability was enhanced by the accumulation of hydrophilic compounds whereas the shear rate limited the membrane clogging by the lipids. The RD filtration using a PAN membrane presented the best performances.

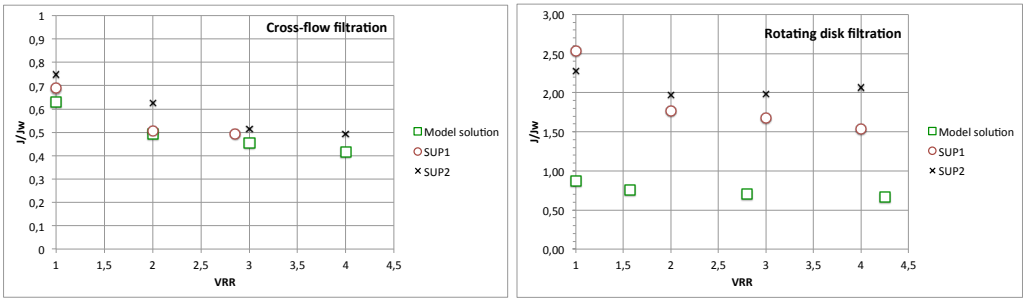

Figure 1. Crossflow and rotating-disk filtrations of an emulsion (model solution of concentrated microalgae aqueous extract) and two real aqueous extracts (SUP1 and SUP2) with a PAN membrane.

4. Conclusions

The membrane filtration is a relevant separation process to concentrate the lipids, reduce the volume of water to treat for further purification steps and it offers interesting opportunities for the fractionation of biomolecules from microalgae. An optimization of the coupling with the upstream operations (culture, cells disruption, clarification) would enhance the separation.

References

[1] E. Clavijo Rivera, V. Montalescot, M. Viau, D. Drouin, P. Bourseau, M. Frappart, C. Monteux, E. Couallier, Bioresource Technology, 256 (2018) 77 - 85