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Bioactive Polymer Membranes for Protein Recovery from Microalgae

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Abstract

Microalgae are a promising source of nutrients, offering significantly higher production yields compared with crops such as maize or rapeseed. In addition, their cultivation does not require arable land or freshwater. Within the European Union, several microalgal strains have already been included in the list of approved food sources. At present, however, the recovery of valuable biomolecules such as proteins from microalgae remains limited by several factors. To fully exploit the potential of microalgae, cell disruption followed by efficient separation of their cellular components is required. Most biomolecules present in green microalgae or in disrupted cells are assembled into complex structures or aggregates, making an additional disassembly step necessary to enable the recovery of selected biomolecules by membrane filtration. Initial studies have shown that the application of different enzymes to corresponding algal extracts can significantly improve the extraction of proteins from such aggregates.(Schmidt et al., 2022) In the work presented here, the use of suitable enzymes immobilized on microfiltration membranes was investigated with the aim of enhancing protein recovery. For this purpose, digestive enzymes were immobilized on polymer membranes by electron-beam grafting.(Schreiber et al., 2025) The resulting enzymatic membranes were subsequently applied in the sequential filtration of *Tetraselmis chui* extracts.(Poidevin et al., 2025) Within the scope of this study, different enzymes were immobilized on microfiltration membranes both individually and in combination. In addition, various filtration conditions for the algal extracts were analyzed and optimized using statistical experimental design. A highly efficient enzymatic membrane was identified, and further investigations were carried out to better understand its beneficial effect in terms of reduced membrane fouling and/or the degradation of biomolecular aggregates. The results of this work demonstrate that enzymatic lysis in combination wagnes.schulze@iom-leipzig.deith membrane filtration can be successfully applied to recover valuable biomolecules such as proteins from a complex mixture of algal extracts in a simple filtration process. The application of AI-based methods enabled the development of highly efficient biocatalytically active membranes and the optimization of algal extract filtration conditions with significantly reduced experimental effort.

Keywords: enzyme immobilization, algae filtration, membrane fouling, protein recovery