Microalgae Pre-Concentration Technologies for Sustainable Biofuel Production: Insights from the ALGAESOL Horizon Europe Project

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INTRODUCTION

Microalgae have emerged as a promising feedstock for renewable fuels due to their rapid growth rates, high lipid content, and ability to treat wastewater while converting CO_2 into organic compounds with the energy provided from sunlight[1]. However, the commercialization of microalgae-derived biofuels remains hindered by high production costs, particularly during the energy-intensive biomass harvesting.

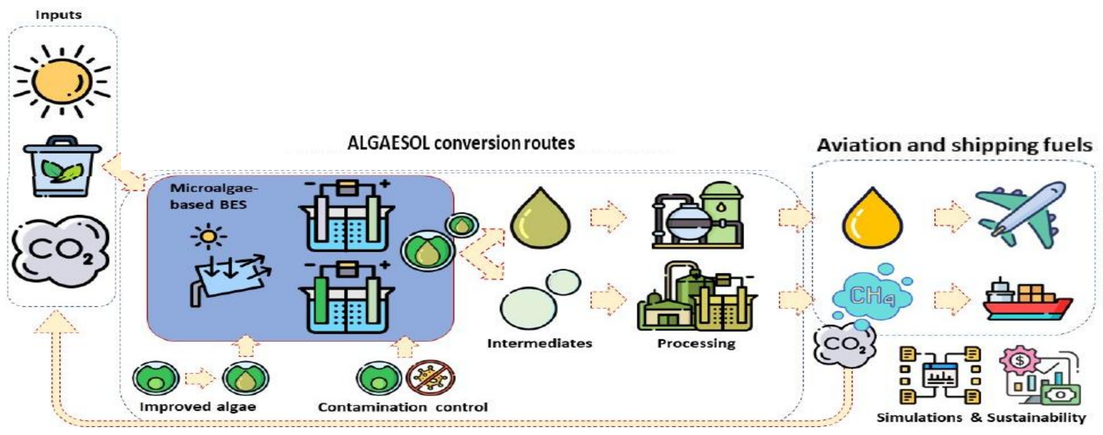
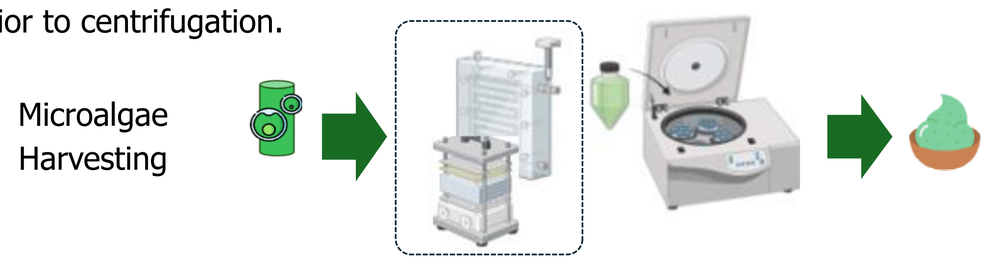


Figure 1. Schematic overview of the ALGAESOL project concept.

The ALGAESOL Horizon Europe Project (grant agreement No. 101147112) addresses these challenges, focusing on developing scalable, energy-efficient microalgae pre-concentration (factor >10) technologies using membrane systems prior to centrifugation.

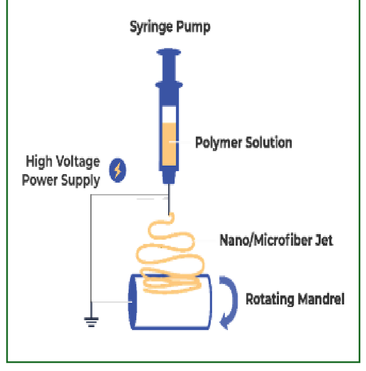


Membrane pre-concentration step

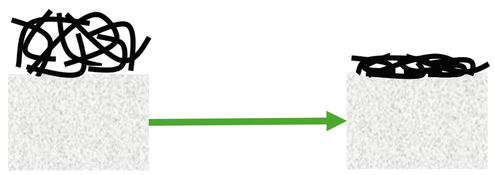
LEITAT is working on the development of electrospun nanofiber membranes, suitable for both pressurized and submerged membrane filtration systems.

MEMBRANE DEVELOPMENT & CHARACTERIZATION

Electrospinning technique

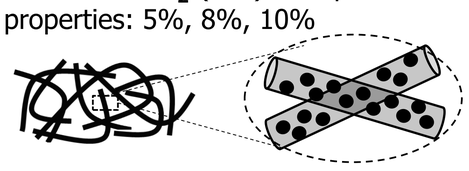


Polyacrylonitrile (PAN) polymer over PET as non-woven support



Nanofiber Functionalization

→ the incorporation of **TiO_2** (P25) nanoparticles for anti-fouling and self-cleaning properties: 5%, 8%, 10%



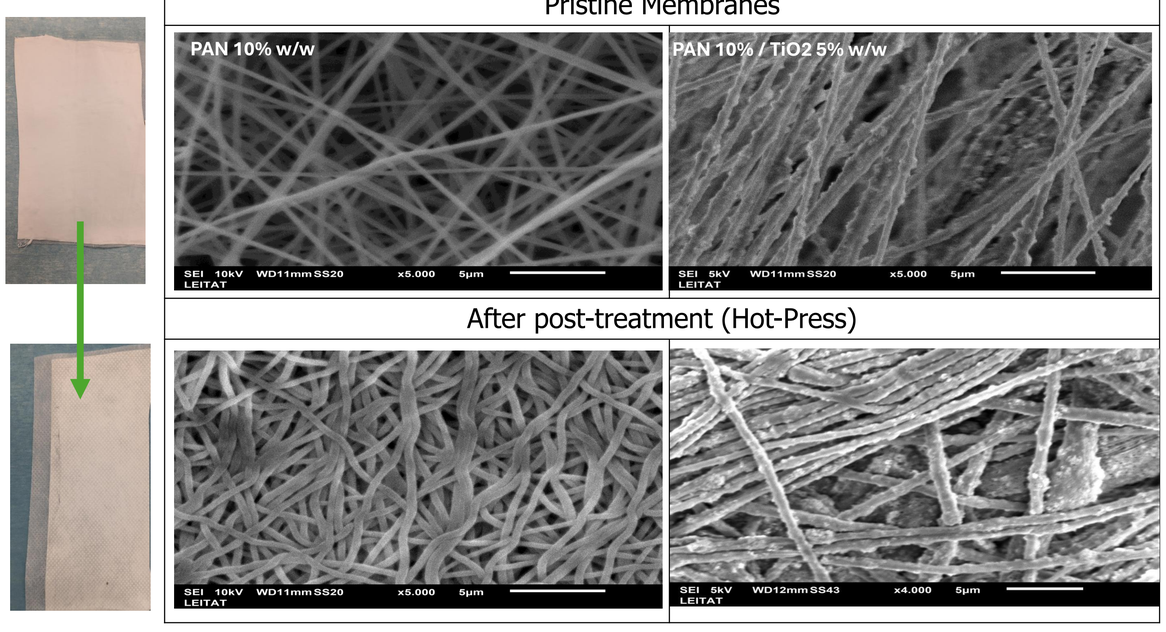


Figure 2. SEM images of pristine and post-treated membranes: PAN 10% and PAN 10% + 5% TiO2.

Table 1. Pore size measurement results.

	Smallest pore size (um)	MFP size (um)	Bubble point (um)
MV020	1,263	1,448	4,101
(7h)_pristine	1,698	1,931	2,341
(7h)_postt	0,987	1,163	2,458
(14h)_pristine	1,408	1,582	2,457
(14h)_postt	0,519	0,571	0,983

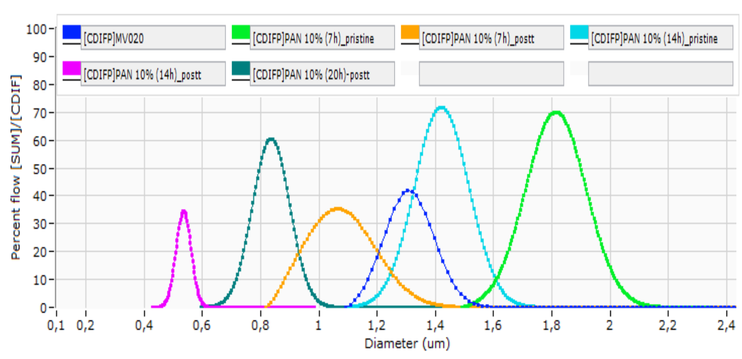


Figure 3. Average open pore size of each membrane before and after post-thermal treatment (hot press).

MICROALGAE CONCENTRATION PERFORMANCE

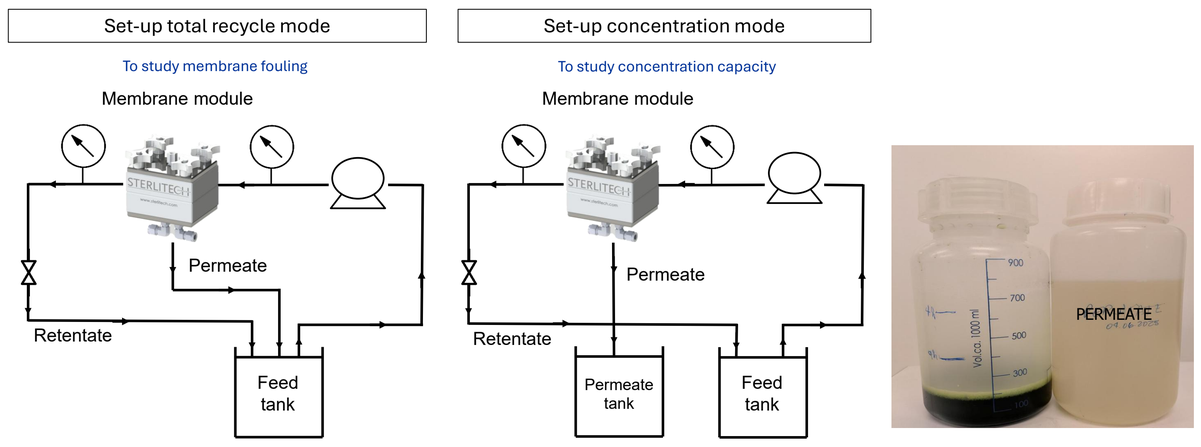
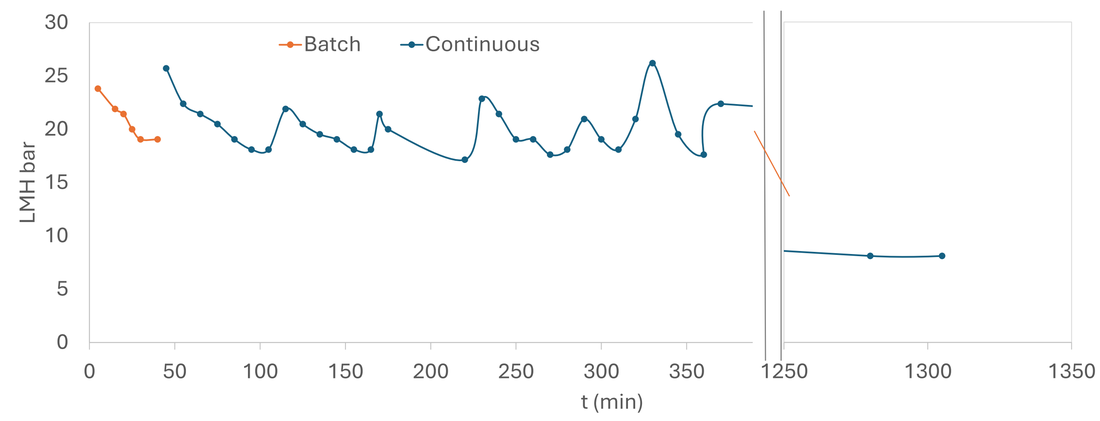


Figure 3. Microalgae concentration performance set-up in two operational modes: batch & continuous.

Table 2. Summary of approaches to improve membrane performance.

Approach	Description
Operational parameters	Intermittent operation: Filtration/Relaxation: 60 min/5 min vs. 30 min/5 min
Chemical cleaning	Intermediate chemical cleaning with 0.75% NaOCl

(A) Commercial Membrane: MF-MV020/non-woven polyester



(B) Electrospun Membrane: PAN 10% _ **14h**/non-woven polyester

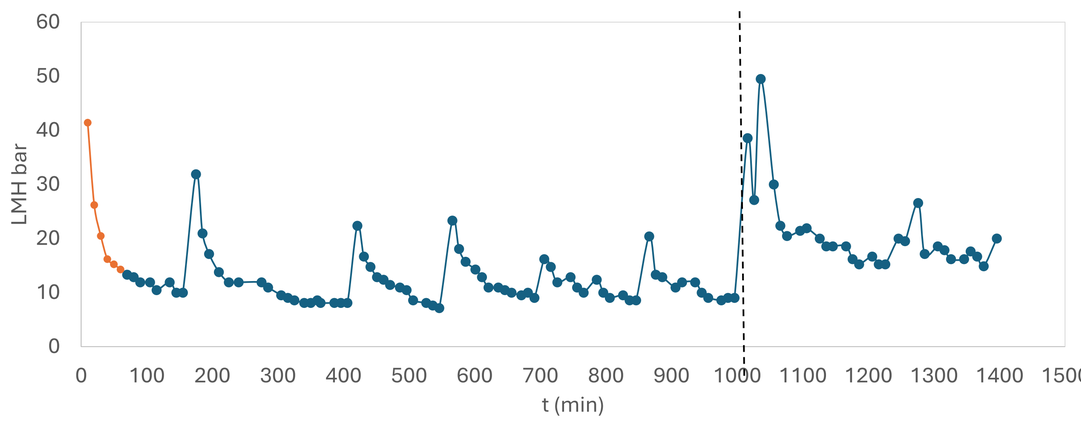


Figure 4. Comparison between (A) commercial and (B) electrospun membranes during semi-continuous operation (alternating filtration and relaxation cycles) for harvesting up to a volumetric concentration factor (VCF) of 10. The discontinuous line denotes a physical cleaning event within the process.

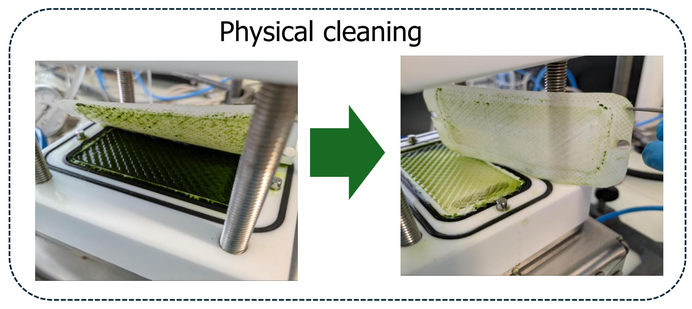


Figure 5. Membrane filtration cell images before and after physical cleaning, illustrating the removal of fouling deposits and restoration of membrane surface condition.

CONCLUSIONS & FUTURE WORK

- The optimized electrospun PAN (10%) nanofiber membrane demonstrates comparable performance to commercially available PVDF microfiltration membranes.
- The membrane demonstrated an effective capacity for algae filtration up to a volumetric concentration factor of 10, with enhanced performance attributed to the control of operational parameters during filtration.

❖ Future work will focus on incorporating photocatalytic nanoparticles, such as TiO_2, into the membrane matrix to confer self-cleaning properties through photocatalytic degradation of foulants.

References

[1] Tuan, H. et al. Phytochemistry Reviews 22, doi:10.1007/s11101-022-09819-y.

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