METHBRANE: Sustainable manufacturing of superhydrophobic membranes for the decarbonization of dissolved methane emissions from anaerobic digesters

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Background and context

This work shows the **main research lines of the MethBrane project (TED2021-131276 A-I00)**: Sustainable manufacturing of superhydrophobic membranes for the decarbonization of dissolved methane emissions from anaerobic digesters.

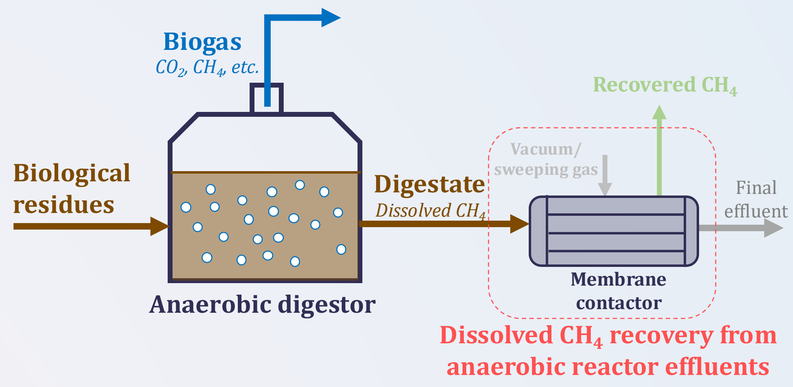
Application of **polymer membrane contactors** as desorption device for the recovery of dissolved CH_4 from anaerobic reactor effluents has attracted the interest [1-4]. These devices achieve gas/liquid mass transfer without dispersion of one phase within another, by passing the fluids on opposite sides of a polymeric membrane. This can be approached using Flat-Sheet Membranes (FSMs) and Hollow-Fibre Membrane Contactors (HFMCs).

Membrane design

The **chosen materials** respond to (i) the current trend of innovation on fluoro-based polyolefines such as PVDF and modified copolymers such as PVFD-HDF which introduce flexibility and improve mass transfer and (ii) bio-based polymers such as CS, which offer reactivity sites for functionalization. The **membranes synthesis/fabrication** will follow non-solvent and thermically induced phase separation (NIPS and TIPS, respectively) and electrospinning (ESP). Surface **functionalisation** consists in grafting fluoroalkylsilane nanolayer(s) onto the casted membranes, drastically increasing the hydrophobicity of the casted membranes.

Membrane design requirements focus on:
(i) Palliate membrane resistance to mass transfer, (ii) Surface hydrophobicity and anti-fouling (iii) Selectivity towards CH_4, y (iv) Mechanical, chemical, and thermal stability.

Application processes



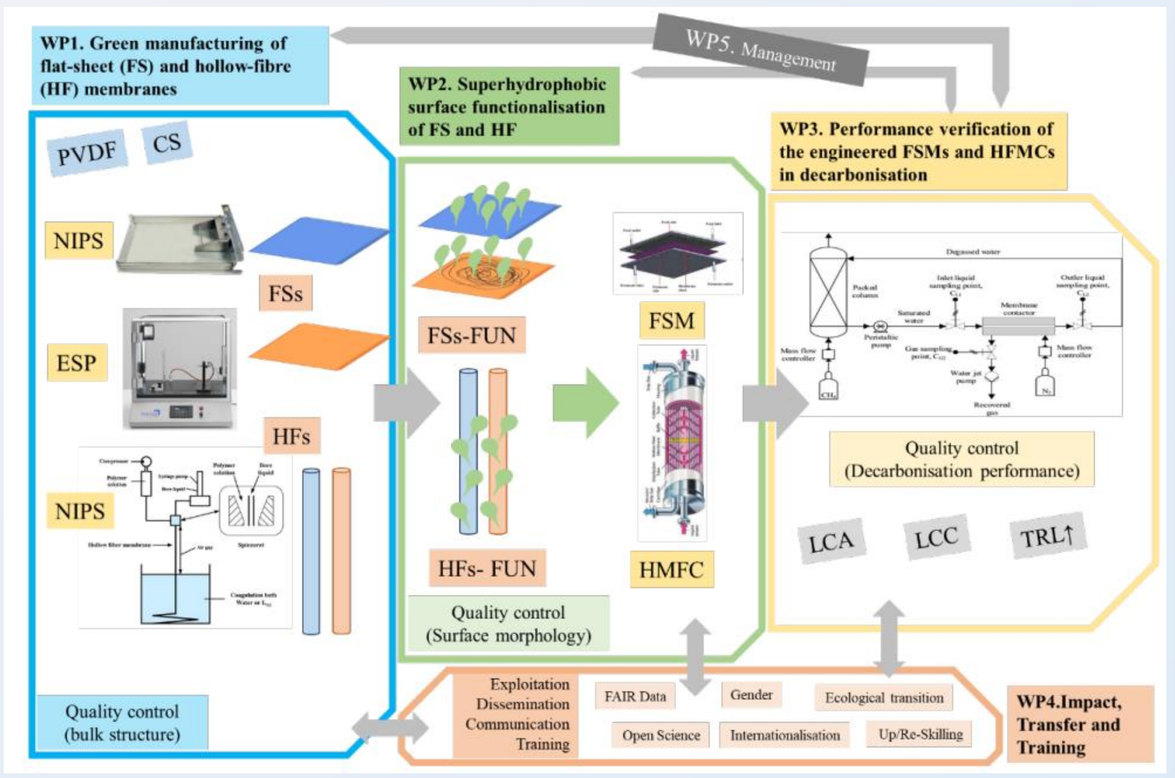
Objectives

The **main objective of MethBrane** is to develop improved polymer-based membrane contactors for the decarbonisation of dissolved CH_4 from anaerobic digesters in waste and wastewater treatment plants.
To fulfil it, **3 strategic technological objectives** are considered:
- ✓ To develop green manufacturing processes for the preparation of flat-sheet (FSM) and hollow fibre (HF) membranes with tailored porosity.
- ✓ To optimize surface functionalisation to achieve superhydrophobicity on FSMs and HFs towards the improvement of stability against wetting and fouling.
- ✓ To optimise the operation of FSMs and HFMCs for the decarbonisation of dissolved CH_4 from anaerobic digesters.

In addition, **2 strategic impact-oriented objectives** related to the external and internal success of the project execution, aimed at developing the impact and ensuring the quality of MethBrane:
- ✓ To develop the transfer of knowledge through the integration and promotion of national and international exploitation, dissemination and communication of the results.
- ✓ To ensure the quality of execution through technical and economic-administrative coordination.

Methodology and work plan

Divided in **4 work packages (WP):**
- **WP1. Green manufacturing of flat-sheet (FS) and hollow-fibre (HF) membranes**: (1) Synthesis of innovative additives for the manufacturing of membranes, (2) Development of PVDF-based and chitosan-based FS/HF membranes, (3) Membrane quality control and assembly of FSMs and HFMC for stability and hydraulic control.
- **WP2. Superhydrophobic surface functionalisation of FS and HF**: (1) Surface functionalisation of PVDF/CS-based FS and HF membranes, (2) Membrane quality control and assembly of functionalised FSMs and HFMC for stability control.
- **WP3. Performance verification of the engineered FSMs and HFMCs in decarbonisation**: (1) Dissolved CH4 recovery efficiency of engineered FSM and HFMC in short-term operation, (2) Long-term CH4 degassing, fouling and cleaning strategies, (3) Analysis of environmental, technical and economic viability of the technologies.
- **WP4. Impact, Transfer and Training**: (1) Exploitation, (2) Dissemination, (3) Communication, (4) Training.



References

[1] B. C. Crone, et al. Water Research, 2016, doi: 10.1016/j.watres.2016.08.019, [2] S. Heile, et al. Sep. Purif. Technol., 2017, doi: 10.1016/j.seppur.2017.08.021, [3] W. Rongwong, et al, NPJ Clean Water 2018, doi: 10.1038/s41545-018-0021-y, [4] E. Centeno Mora et al. Rev. Environ. Sci. Biotechnol., 2020, doi: 10.1007/s11157-020-09546-w

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