




OITB service catalogue



The project has received funding from the European Union's Horizon 2020 research and innovation program under Grant Agreement N° 862330.

Structure of the catalogue and service providers

Pilot Lines: list of the 14 pilot lines under upgrading activities in the project

Services offered by the OITB and accessible through the Open Calls application

■ Technical services

- Membrane properties characterisation techniques
- Membrane scale up (equipment and techniques)
- Development and scale up of membranes
- Engineering & Design

■ Non-technical services

- Data management
- Software development
- Venturing activities
- Techno-economic analysis and market validation
- Consultancy
- Innovation services





PILOT LINES

List of the 14 pilot lines under upgrading activities in the project

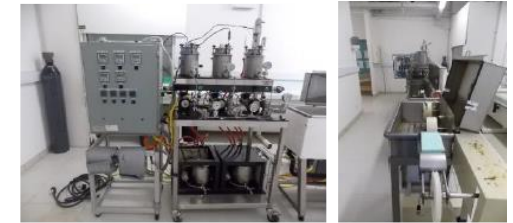
Upscale/upgrade of 14 pilot manufacturing lines

- PL1 Dual layer mixed matrix HF manufacturing system
- PL2 Pd-based membrane plating system
- PL3 Grafting of ceramic membranes
- PL4 Nanostructured inorganic micro-tubular-membranes
- PL5 Flat sheet polymer membrane production.
- PL6 Zeolite membranes
- PL7 Roll-to-Roll coating of advanced nanophase-segregated ion-exchange polymer membranes



Upscale/upgrade of 14 pilot manufacturing lines

- PL8 Surface nano-structured and functionalized HF's
- PL9 Modification of HF's by microfluidics
- PL10 In-line modification of nano-coatings on hollow fiber membranes via E-beam
- PL11 GO/CNTs mixed-matrix membrane system
- PL12 Molecular sieving nanoporous ceramic and CNT membranes system
- PL13 Hollow fiber membrane spinning with improved geometric features
- PL14 Centrifugal potting of HF membranes





INNOMEM CATALOGUE

OITB technical services for nano-enabled Membranes

Membranes properties characterisation techniques

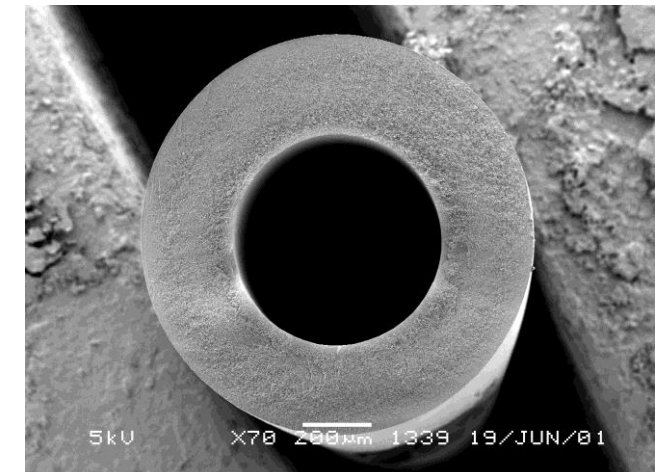
PHYSICO-CHEMICAL CHARACTERIZATION TECHNIQUES

EXPERTISE & CAPABILITIES

- Surface and bulk characterisation, electrokinetic measurements
- Laboratory rigs for membrane performance assessment

ANALYTICAL EQUIPMENT

- SEM, FE-SEM, EDX, SAXS, TEM, AFM, XRD, XPS, Raman spectroscopy, AFM, FTIR, MALDI-TOF, STED, Confocal, TGA, DSC, FLIM, Ellipsometry, QCMD, EIS, HPLC, GC, ion chromatography, Zeta-potential (**CNR, RWTH, TUE, EMI Twente, Hereon, UM**)
- Physico-chemical and performance characterization of membranes in a wide variety of liquid membrane processes (**VITO**)
- Permporometry (**EMI Twente, Hereon**)
- Analytics and surface analytics of materials (**UDE**)
- Laboratory rigs for membrane performance assessment (**ICL, AU, TUE, TEC, Hereon**)
- Electrokinetic analyzer for solid surface analysis (**UM**)
- Porosimetry (pore size and pore size distribution (**UM**))



Development and scale up of membranes

POLYMERIC MEMBRANES – HOLLOW FIBER

EXPERTISE & CAPABILITIES

- Development of recipes
- Fabrication of thin films composites
- Membrane surface modification
- Development of mixed matrix membranes
- Development by different type of separation processes

MANUFACTURING FACILITIES UP TO SCALE

- Fabrication of Thin film composite membranes, Fabrication of Thin film nanocomposite membranes (**UNIZAR**)
- ALD coating of different materials on various support (**UM**)
- Development of hollow fiber membranes for aqueous and gas applications, ranging from small batches (recipe development), to medium batches (for parameter screening) and larger (pilot) scale batches for ‘proof of concept’ (**EMI Twente, TEC**)
- Membrane surface modification via coating and/or offline/inline E-beam treatment (**EMI Twente**)
- Polymeric and HF membranes: - geometries, Additives, Materials and solvents, Chemistry in a spinneret – simultaneous membrane formation and functionalization (**RWTH**)
- Scale-up spinning membrane recipes, building pilots and large membrane units (**POLYMEM**)



Development and scale up of membranes

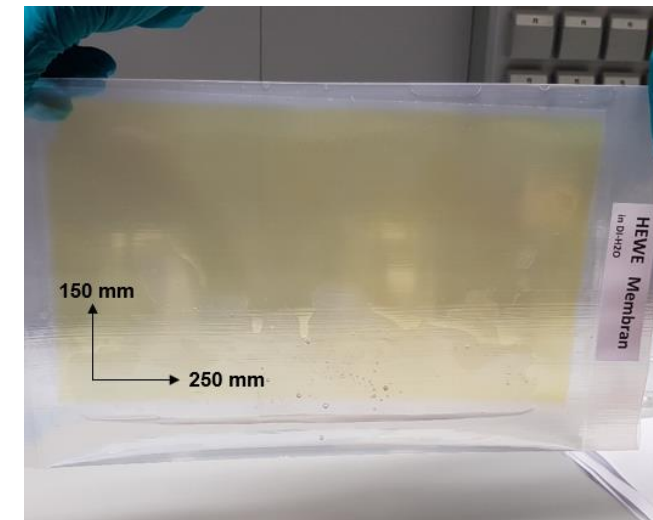
POLYMERIC MEMBRANES - FLAT

EXPERTISE & CAPABILITIES

- Development of recipes
- Fabrication of thin films composites
- Membrane surface modification
- Development of mixed matrix membranes
- Development by different type of separation processes

MANUFACTURING FACILITIES UP TO SCALE

- Development of separation membranes for ultrafiltration, nanofiltration, osmotic separations, membrane distillation and other processes, including micro- and nanostructured or nanocomposite membranes (**UDE**)
- Polymeric membranes for gas and vapour permeation, pervaporation and organic solvent nano filtration manufactured as thin film composite flat sheet membranes and mixed matrix membranes (**Hereon, EMI Twente**)
- Advanced surface functionalization of commercially available membranes (**UDE**)
- Development of porous adsorbers and membranes for contaminant removal from water (**UDE**)



Development and scale up of membranes

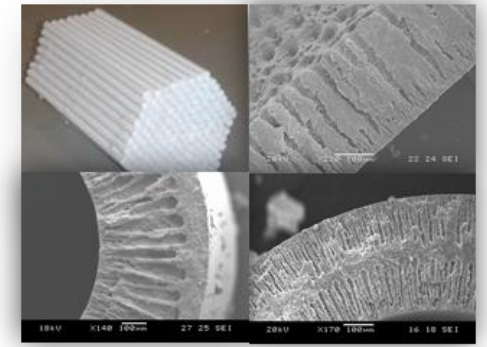
INORGANIC MEMBRANES

EXPERTISE & CAPABILITIES

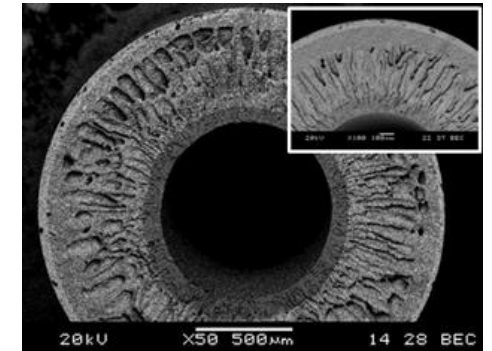
- Multi-channel-tube-structures
- Functionalisation of ceramic membranes
- Catalytic membranes for emission control

MANUFACTURING FACILITIES UP TO SCALE

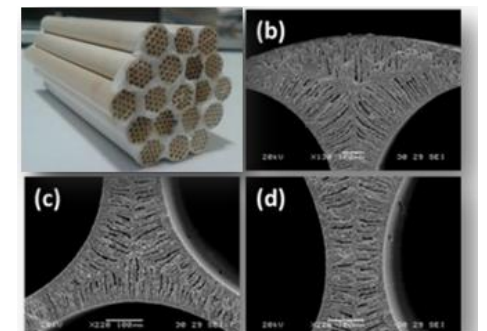
- Production of ceramic membranes for micro-, ultra- and nanofiltration. Large multi-channel-tube-structures for filtration like honeycombs production (**RKV**)
- Development of new methods for efficient functionalization of ceramic membranes, aimed at increased performance in liquid filtrations; extensive feasibility and proof of concept testing from lab to pilot scale in a broad range of separation problems. Unique expertise in Organic Solvent Nanofiltration (**VITO**)
- Manufacturing expertise for Ceramic membranes for water and wastewater treatment; Catalytic membranes for emission control; Ceramic membranes for gas separation, such as CO₂ capture; Ceramic membranes for energy conversion, such as solid oxide fuel cell and electrolysis (**ICL, AU**)



Single-layer



Multi-layer



Multi-channel

Development and scale up of membranes

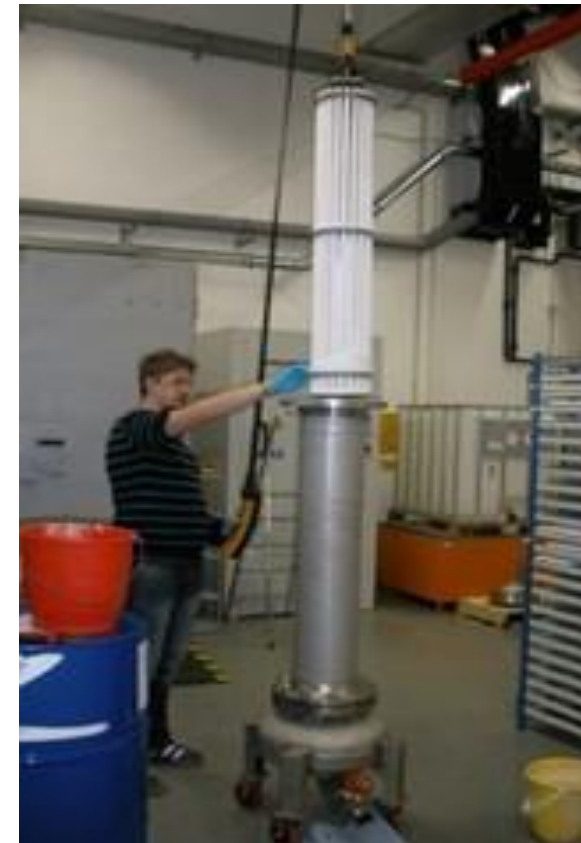
INORGANIC MEMBRANES

EXPERTISE & CAPABILITIES

- Fabrication of tubular inorganic membranes for gas separation
- Fabrication of metallic capillary membrane

MANUFACTURING FACILITIES UP TO SCALE

- Metallic membranes (i.e. Pd-based thin film membranes by electroless plating) (**TEC**)
- Carbon molecular sieve membranes by dip coating (**TEC**)



Membrane modules

DESIGN AND PRODUCTION OF MEMBRANE MODULES

EXPERTISE & CAPABILITIES

- Potting of membranes
- Sealing of membranes
- Selection of glues
- Selection of housing materials

MANUFACTURING FACILITIES UP TO SCALE

- Membrane modules for gas separation, distillation, contactors, etc; (**CNR**)
- Membrane modules and reactors (**TEC/TUE**)
- HF module design and prototyping, design of the production lines with process optimization (**MESEP**)
- Design of modules for gas separation (**Hereon**)
- Design and fabrication of hollow fiber membrane modules via potting centrifuge (**EMI Twente**)
- Module fabrication to large size module (the largest module fabricated so far contain 550 m² of hollow fibers (200 000 HF) (**POLYMEM**)
- Module and spacer design and flow MRI analytics (**RWTH**)



Membrane lab scale testing equipment

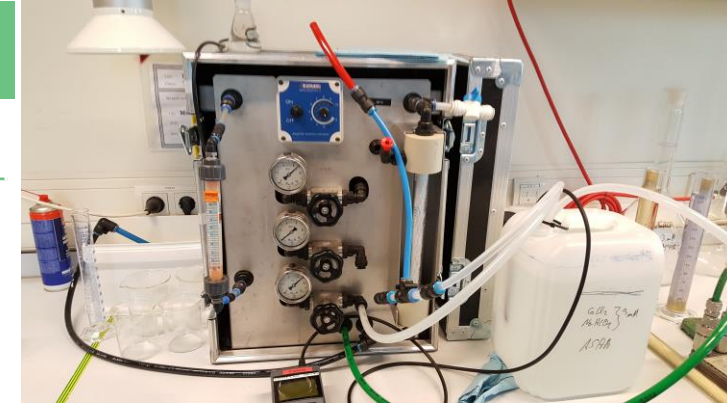
PILOTING FOR DIFFERENT APPLICATIONS

EXPERTISE & CAPABILITIES

- Flexible lab-scale equipment for performance testing in different applications

UPSCALING FACILITIES

- Reverse osmosis, nanofiltration, ultrafiltration, microfiltration, membrane condensers, membrane contactors, membrane distillation (**CNR, VITO, EMI Twente, Hereon**)
- Organic Solvent Nanofiltration (**VITO, EMI Twente, Hereon**)
- Pervaporation (**VITO, EMI Twente, Hereon**)
- Electrodialysis (**VITO, EMI Twente**)
- Vapor permeation (**EMI Twente**)
- Test equipment for membrane-dewatering of solvents (**DBI**).
- Micro-/Ultra-/Nanofiltration from laboratory scale to pilot testing and analysis of the results using HPLC, photometer, etc. (**RKV**)
- Automatic time lag permeation apparatus (**TEC, Hereon**)



Membrane lab scale testing equipment

TESTING FOR DIFFERENT APPLICATIONS

EXPERTISE & CAPABILITIES

- Flexible lab-scale equipment for robustness testing for different applications

UPSCALING FACILITIES

- High pressure gas permeation testing setup (pure and gas mixtures):
 - Up to 60 bar (**TUE, DBI**)
 - up to 100 bar (**TEC**)
- Permeation (single gas and dehumidification) and filtration measurements (MF, UF, NF). Time-lag of different gases up to 70 °C (**UNIZAR**).
- Pilot scale units for the investigation of mixed gas permeation performance up to 20 m² module scale, 65 bar feed pressure and 250°C feed temperature, gas separation, vapour permeation, organic solvent nanofiltration and pervaporation modules (**Hereon**)
- Modules autopsy (**POLYMEM, EMI Twente**)
- Separation performance and long-term stability of membranes up to 65 bar (**Hereon**) and 50 bar (**TUE, DBI**) in mixed and single gas environments.



Membrane pilot testing equipment

PILOTING FOR DIFFERENT APPLICATIONS

EXPERTISE & CAPABILITIES

- Flexible lab-scale equipment for aqueous as well as organic solvent filtration fit for down-stream purifications, gas separation but also for reaction-separation coupling.

TEST FACILITIES/PILOTS

- Mobile pilots for liquid filtration, both water and organic solvent filtration (ATEX). Some of them are also fit for GMP applications or high temperature applications (**VITO**);
- Test equipment for membrane-dewatering of solvents (**DBI, Hereon**).
- Pilot installations for gas and liquid separation testing: - Ultrafiltration - Nanofiltration - Reverse Osmosis - Organic Solvent Nanofiltration - Electrodialysis – Pervaporation, High pressure and temperature mixed gas permeation setups (**EMI Twente**)

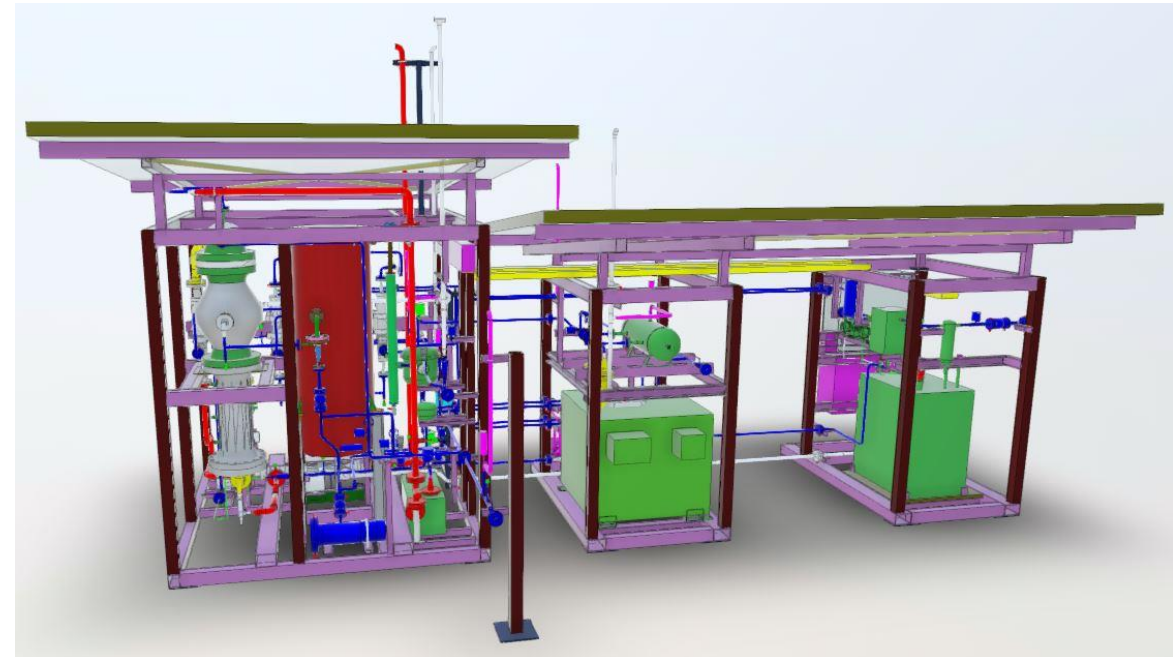


Membrane process design

PROCESS DESIGN FOR DIFFERENT APPLICATIONS

EXPERTISE & CAPABILITIES

- Process development and optimization
- Design of gas membrane-based processes and reactors solving industrial purification and/or process intensification problems (**TUE**)
- Design of liquid membrane-based processes solving industrial purification and/or process intensification problems (**VITO, EMI Twente, Hereon**)
- Design of gas membrane-based processes solving industrial purification and/or process intensification problems (**DBI, EMI Twente**)
- Design of processes, hybrid and integrated processes for gas separation. Performances and process simulation (**Hereon, EMI Twente**)
- Liquid processes (such as removal of organic micropollutants, pesticides from water, separations in organic solvents etc.)
- Gas separation processes (H₂ production, CO₂ capture, biogas upgrade, gas purification, air separation)



Modelling & simulation

PROCESS DESIGN MODELLING AND SIMULATION

EXPERTISE & CAPABILITIES

- Process Design modelling, simulation for the development of membrane modules
- Prediction of topological, transport, separation and/or barrier properties, geometry characterization and 3D reconstruction.

COMPUTER AIDED...

- Modelling and simulation of mass transport (**CNR**)
- Modelling of membrane modules and reactors (**TEC/TUE**)
- Design and prediction of topological, transport, separation and/or barrier properties, geometry characterization and 3D reconstruction from SEM images (**FORTH**)
- Design of modules, processes, hybrid and integrated processes for gas separation. Performances and process simulation. (**Hereon**)
- Nanofiltration/gas separation processes/electrodialysis/swelling of modelling, molecular simulations in nanoporous materials, Ab Initio (Quantum. Calculations on molecular materials and process design (**EMI Twente**))
- Simulation from pore-size to process level (**RWTH**)

Building custom equipment

TUNED TO WISHES OF CLIENT

ENGINEERING CAPABILITIES

- Tuned to wishes of client

EQUIPMENT

- Construction and installation of membrane filtration units for water and wastewater filtration (**POLYMEM**).
- Engineering and construction of hollow fiber spinning lines (ranging from lab scale to pilot scale), spinnerets, potting centrifuge (**EMI Twente**)
- Construction of module manufacturing equipment (**MESEP**)
- Construction of Pervaporation equipment (**TUE**)
- Additive manufacturing techniques for prototyping and device manufacturing (**RWTH**)



INNOMEM CATALOGUE

OITB non-technical services

Non technical services

DATA MANAGEMENT

EXPERTISE & CAPABILITIES

Software FURTHRmind for research data management; Consultancy on data management; Training on FAIR research data management; Rental of server capacity. **(FURTHR, TUE)**

SOFTWARE DEVELOPMENT

EXPERTISE & CAPABILITIES

Software FURTHRmind: Customized software development, programming as a service; Programming expertise: Python, Qt. **(FURTHR)**

VENTURING ACTIVITIES

EXPERTISE & CAPABILITIES

Support in corporate venturing activities to accelerate innovation in companies (B2B “deep tech” breakthrough innovation), addressing the business opportunity maturation process from challenge identification, scouting, acceleration, IP transfer, market validation. **(VNTRS)**



Non technical services

TECHNO-ECONOMIC ANALYSIS AND MARKET VALIDATION

EXPERTISE & CAPABILITIES

Techno-economic evaluations of membrane-based processes. Market studies for proposed technological solutions on green gases, Techno-economic evaluations of technologies. (**VITO, TUE, DBI, ENGIE**)

CONSULTANCY

EXPERTISE & CAPABILITIES

Module design, R&D activities in module development, Set up of the production process. desktop or consultancy work, feasibility studies, characterization of membrane samples, membrane development up to first prototype, application studies, small scale piloting, benchmarking, troubleshooting and building of customized equipment. (**MESEP, EMI Twente, Hereon**)

BUSINESS INNOVATION SERVICES

EXPERTISE & CAPABILITIES

Market & Technology Trends Analysis; finding collaboration and scouting solution providers; tailored grant scan for public funding (**PNO**);

Definition of the value proposition and Unique Selling Points; Preparation of an elevator pitch; Development of a market roadmap (**Tecnalia Ventures**)



Acronyms and the organisations they represent

ACRONYM

ORGANISATION

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- | | |
|--------------|--|
| • AU | • <u>Aston University</u> |
| • CNR | • <u>Consiglio Nazionale delle Ricerche</u> |
| • DBI | • <u>DBI Gas- und Umwelttechnik GmbH</u> |
| • EMI TWENTE | • <u>European Membrane Institute Twente</u> |
| • FORTH | • <u>Forth Institute of Chemical Engineering Sciences</u> |
| • FURTHR | • <u>Furthresearch GmbH & Co. KG</u> |
| • HEREON | • <u>Helmholtz-Zentrum Hereon</u> |
| • ICL | • <u>Imperial College of Science Technology and Medicine</u> |
| • MESEP | • <u>MESEP</u> |
| • PNO | • <u>PNO Innovation Unipessoal Lda</u> |
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Acronyms and the organisations they represent

ACRONYM	ORGANISATION
• POLYMEM	• <u>POLYMEM</u>
• RKV	• <u>Rauschert Kloster Veilsdorf GmbH</u>
• RWTH	• <u>Rheinisch-westfaelische Technische Hochschule Aachen</u>
• TEC	• <u>Fundación Tecnalía Research & Innovation</u>
• TUE	• <u>Technische Universiteit Eindhoven</u>
• UDE	• <u>Universitaet Duisburg-Essen</u>
• UM	• <u>Université de Montpellier</u>
• UNIZAR	• <u>Universidad de Zaragoza</u>
• VITO	• <u>Vlaamse Instelling voor Technologisch Onderzoek N.V.</u>
• VNTRS	• <u>Tecnalía Ventures</u>



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