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mi micro innova efficient processing
Tüpraş

24 PARTNERS

10 COUNTRIES

6 TESTING SITES

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MACBETH

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MACBETH

Membranes And Catalysts Beyond Economic and Technological Hurdles

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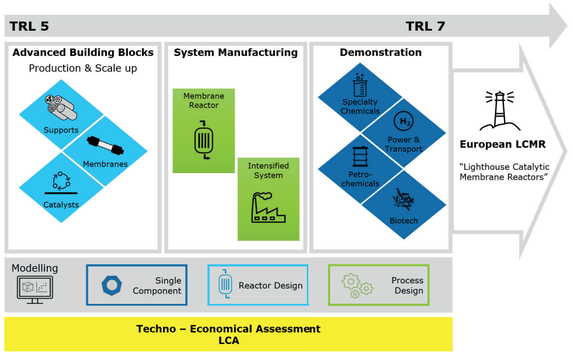
In the process industry, downstream processes are the most energy and resource consuming steps in industrial operations. To contribute to Europe's goal of a clean and liveable environment, new processes are required that have a **very broadly applicable concept for an efficient integration of downstream operations** in the overall process chain to reduce CAPEX and OPEX and therefore significantly enhance the competitiveness of the European process industry.

The **MACBETH** consortium provides a **breakthrough technology by combining catalytic synthesis with the corresponding separation units in a single, tailor-made, highly efficient catalytic membrane reactor** (CMR). Within MACBETH for the first time 24 partners with manifold expertise and competencies in membrane technology are united to successfully transfer the technological concept to other sectors of the chemical industry.

Fundamental developments and the outreach of the EU funded projects ROMEO, BIONICO and CARENA proofed the concept for CMRs at TRL 5 and pilot plants have been operated for highly relevant and large-scale processes: i) **Hydroformylation** (HYFO), ii) **Hydrogen production** (H2) and iii) **Propane dehydrogenation** (PDH). Now, key members of these consortia have **joined forces in MACBETH** to bring CMR to the level of TRL 7 as basis for the commercialisation of the three novel technologies and to transfer it to **almost any sector** of the process industry requiring separation after catalytic synthesis.

To demonstrate the exploitation potential, MACBETH will extend the CMR technology to the field of biotechnology using bacteria or enzymes as special types of catalysts. In this field, the selective enzymatical cleavage of fatty acids is of particularly high commercial interest. Based on a large variety of already established building blocks (such as catalysts, membranes, support materials and reactor concepts) a demo plant for **bio-catalytical oil cleavage** (BOC) will be developed, showing the **commercial applicability of CMR in biotechnology** for the first time.



CASES

HYFO – Hydroformylation
The conversion of olefins and syngas to aldehydes, is a key reaction in chemical industry to produce specialty chemicals. HYFO case will focus on the optimization of: i) Support material and structure for efficient use of the catalytic system, ii) catalytic system to increase yield and selectivity, iii) polymeric membrane for separation efficiency and permeate flow and iv) operating parameters.
For demo phase, HYFO case will be placed in bypass to the conventional hydroformylation production plant at Evonik's Marl site for real industrial-scale conditions.

H2 – Hydrogen Production
In H2 case, natural gas or biogas methane will be con-verted to H2 at a much lower temperature by using a novel reactor concept integrating H2 separation in situ during the reforming reaction in a single vessel. This will increase the overall process efficiency (from 59% to more than 70% (for biogas)) and decrease volumes & components (e.g. auxiliary heat management units) resulting in much lesser CAPEX and OPEX.
Demo reactors will be tested in a real biogas plant (H2a) at ENGIE and in a plant for natural gas (H2b) in the CNH2 facilities.

PDH – Propane Dehydrogenation
PDH case technology will mitigate the required hash conditions of selective propane dehydrogenation by optimized low temperature operation resulting in the avoidance of catalyst deactivation. This will lead to less regeneration steps, improved process management and longer plant/ catalyst lifetime. Additionally, the improvement of propylene selectivity significantly reduces gaseous side products in the process stream.
A smart design of PDH optimized CMR system will be established and implemented in a demo plant at ENGIE.

BOC – Bio Catalytical Oil Cleavage
The BOC case will develop a CMR-based reactor combining enzyme-catalysed selective hydrolysis of oil fatty acids in an aqueous-organic system followed by an integrated membrane separation to isolate selected fatty acids. Supported by all MACBETH cases, tailor-made building blocks will be developed for a time-efficient transfer of the entire system to an industrial pilot plant. For local flexibility, a containerized setup of the system is foreseen.
The BOC case reactor will be demonstrated on 2 testing sites at Enzymicals and SOLUTEX.

IMPACT

- **Reduce greenhouse gas (GHG)** emissions of large volume industrial process **by up to 35%** — ↓ ≤ 35%
- **Resource and energy efficiency** will be increased **by up to 70%** — ↑ ≤ 70%
- **CAPEX is decreased by up to 50%**
- **Substantially smaller and safer** production plants — ↓ ≤ 50%
- **OPEX by up to 80%** — ↓ ≤ 80%

European **"Lighthouse Catalytic Membrane Reactors" (LCMR)**

The ultimate MACBETH project objective is to fully exploit the potential of CMR by providing a European competence centre as a "one-stop shop" for all industrial, academic and educational communities in Europe concerned with CMRs and their applications. The LCMR will provide access to the combined knowledge of the MACBETH project with respect to all relevant disciplines such as building blocks, modelling and system integration, valorising the project's results through the structured offering of commercial services to interested stakeholders. Not only the concept and feasibility of it, but already a detailed business plan including partner commitment will be developed during the project. This will guarantee a sustainable implementation and exploitation via the spin-off "Lighthouse Catalytic Membrane Reactors (LCMR)".