

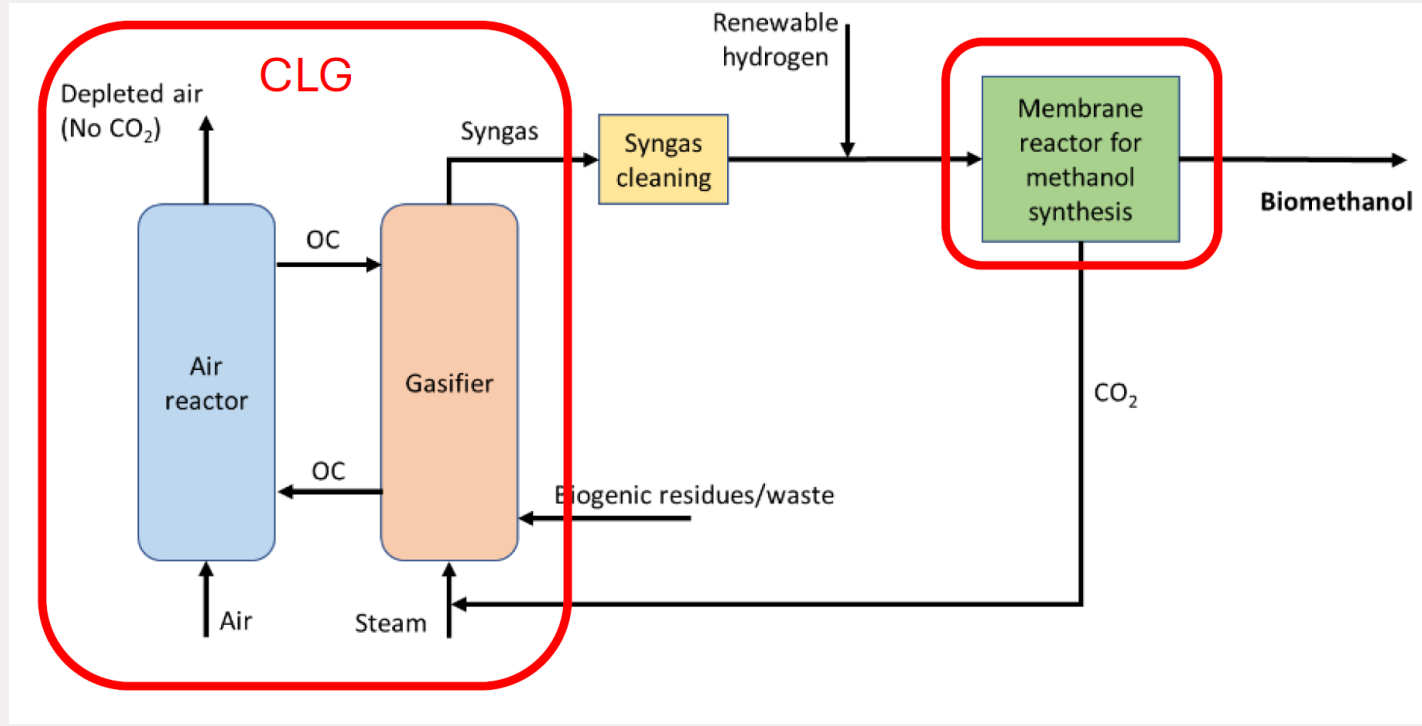
A photograph of a modern, multi-story building with a glass facade and a sign that reads "MICROLAB". The building is set against a clear blue sky. A large tree is in the foreground, partially obscuring the building. The image is overlaid with a semi-transparent blue filter.

Membrane reactors for Methanol and for DME production

Fausto Gallucci, Senior consultant 1CUBE BV, CTO ZEFIRA BV
Part time Professor Inorganic Membranes and Membrane Reactors

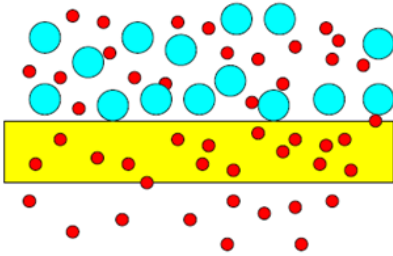


Bio-MeGaFuel Concept(s)



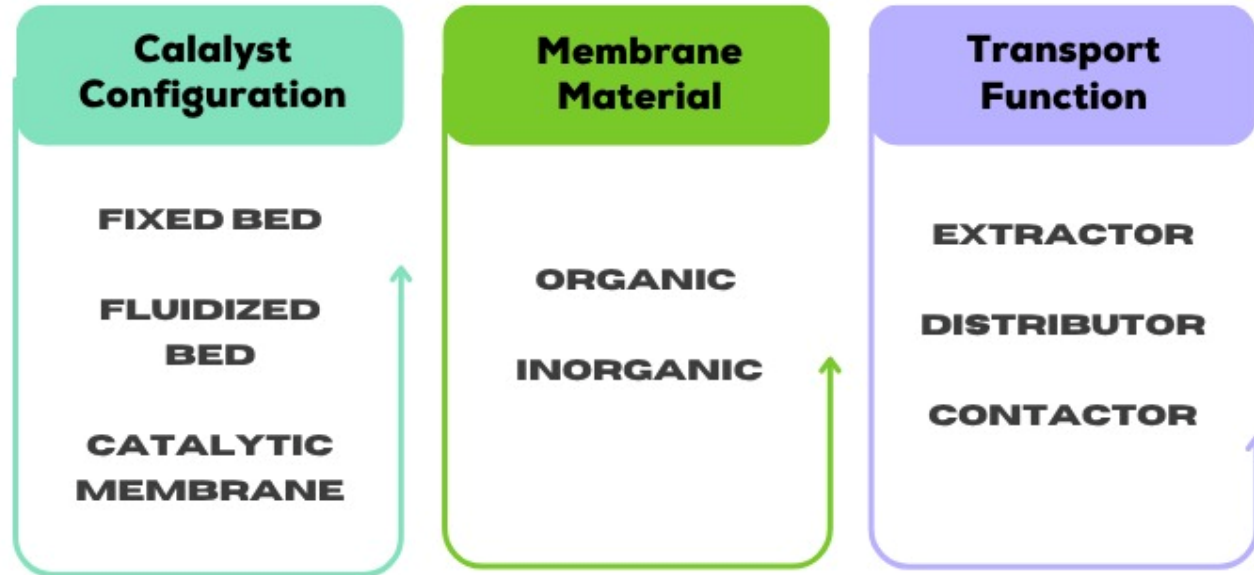
Membrane functions

SEPARATION



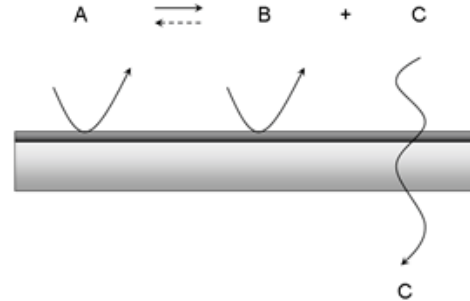
Classification

Membrane Reactors

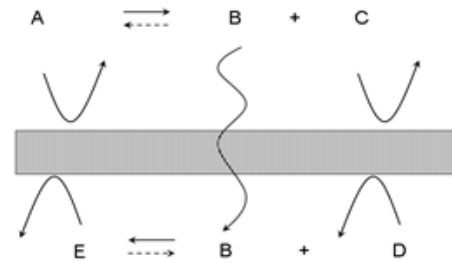


Why a membrane reactor?

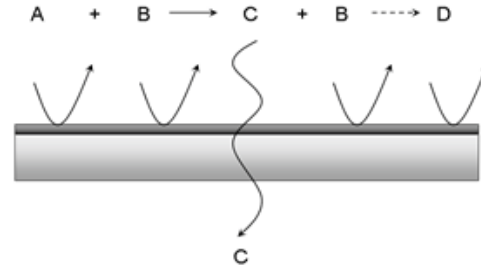
conversion enhancement
by selective permeation
of a reactant product
of an equilibrium
limited reaction



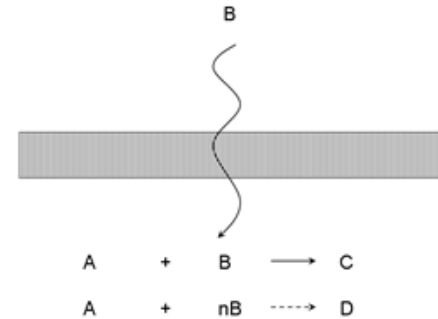
conversion enhancement
by coupling
of reactions



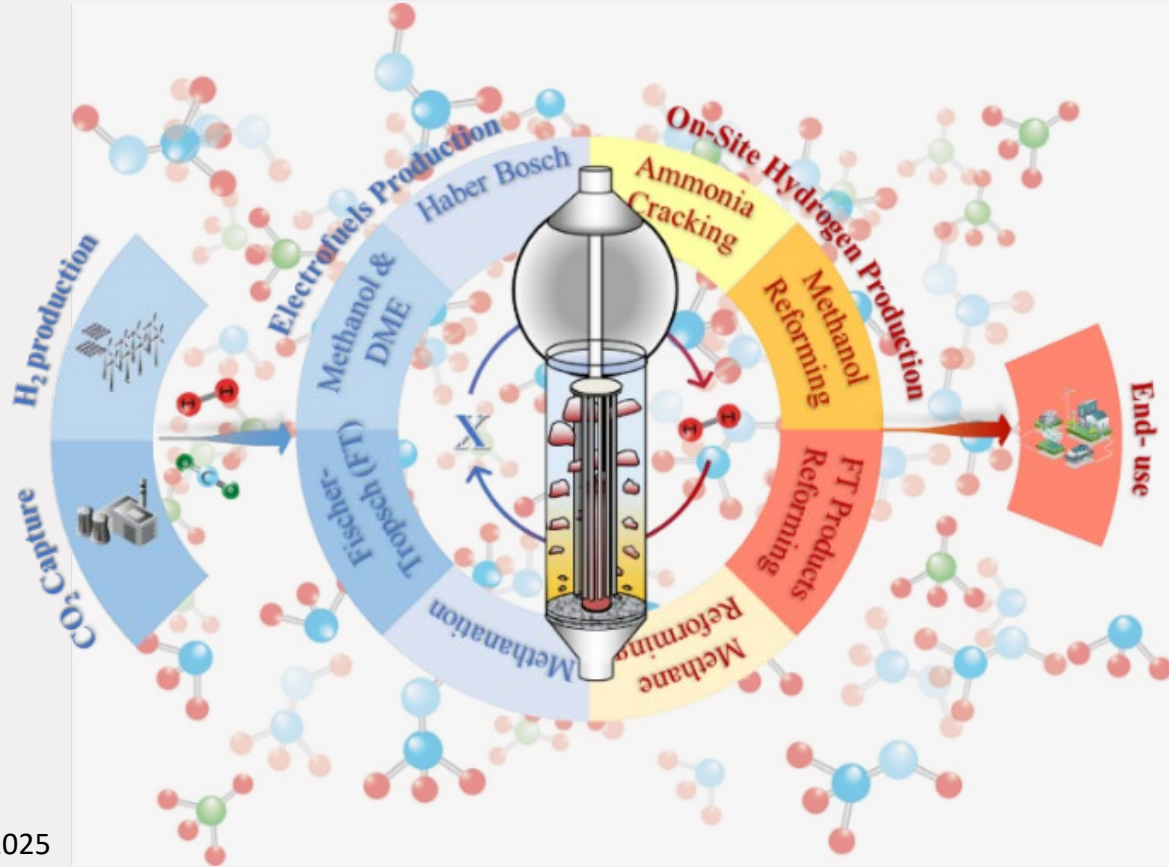
selectivity
enhancement
by selective
permeation of an
intermediate product



selectivity
enhancement
by dosing
a reactant
through the
membrane



Use of MR

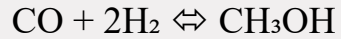


Simon Richard, PhD Thesis, TU/e 2025

Methanol



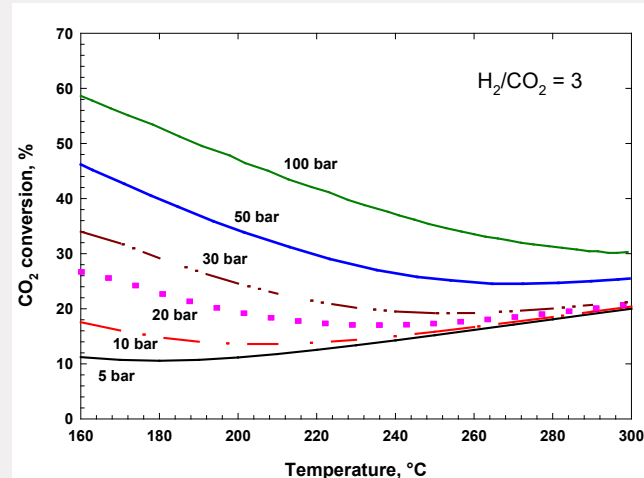
$$\Delta H = -49.5 \text{ kJ/mol}$$



$$\Delta H = -90.7 \text{ kJ/mol}$$

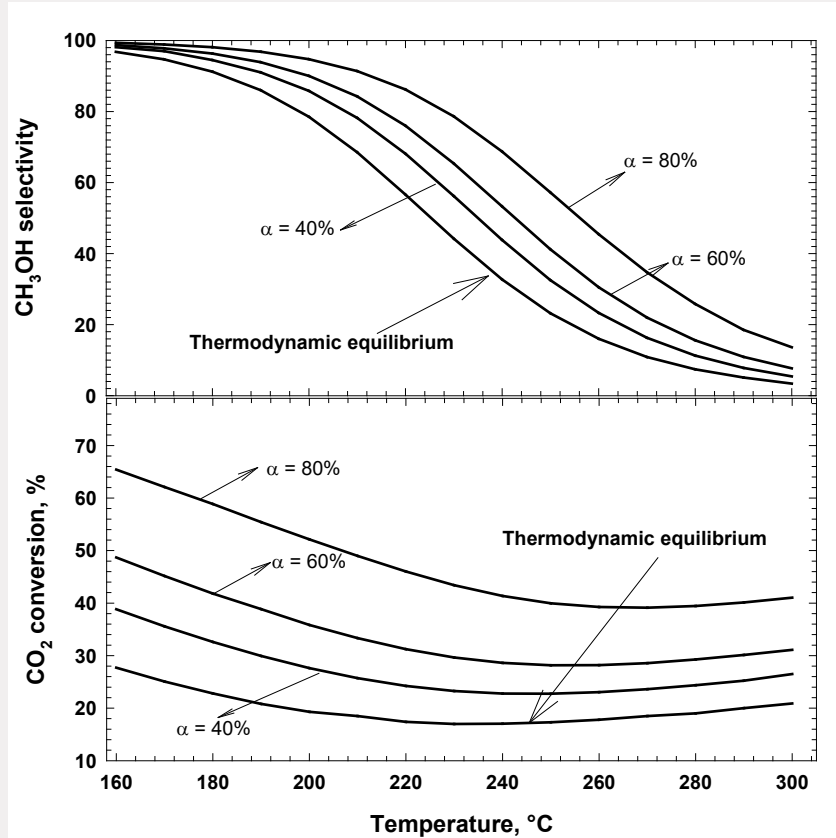


$$\Delta H = +41.2 \text{ kJ/mol}$$



Gallucci et al. *International Journal of Hydrogen Energy*, 2007, 5050-5058

Methanol

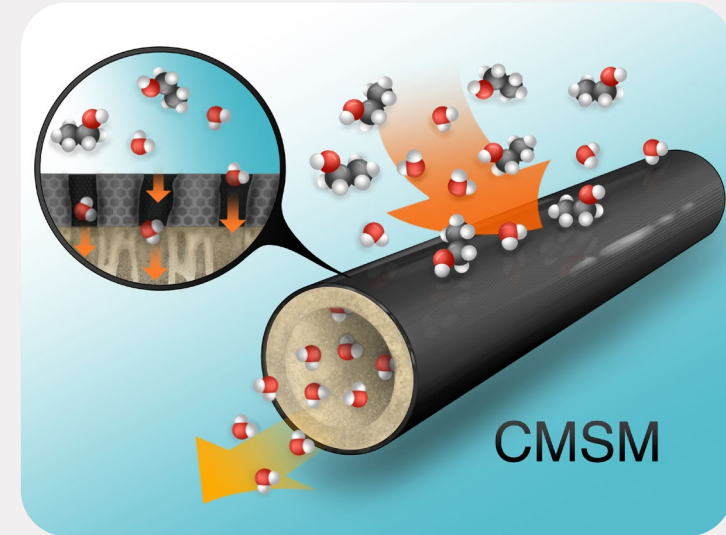
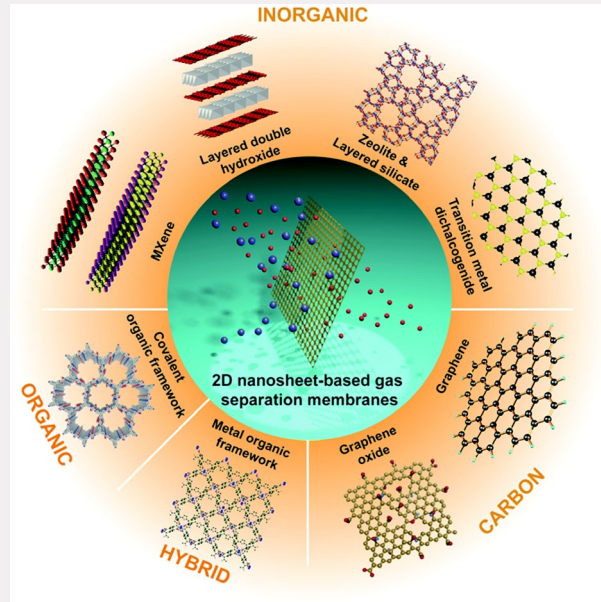


Gallucci et al. *International Journal of Hydrogen Energy*, 2007, 5050-5058

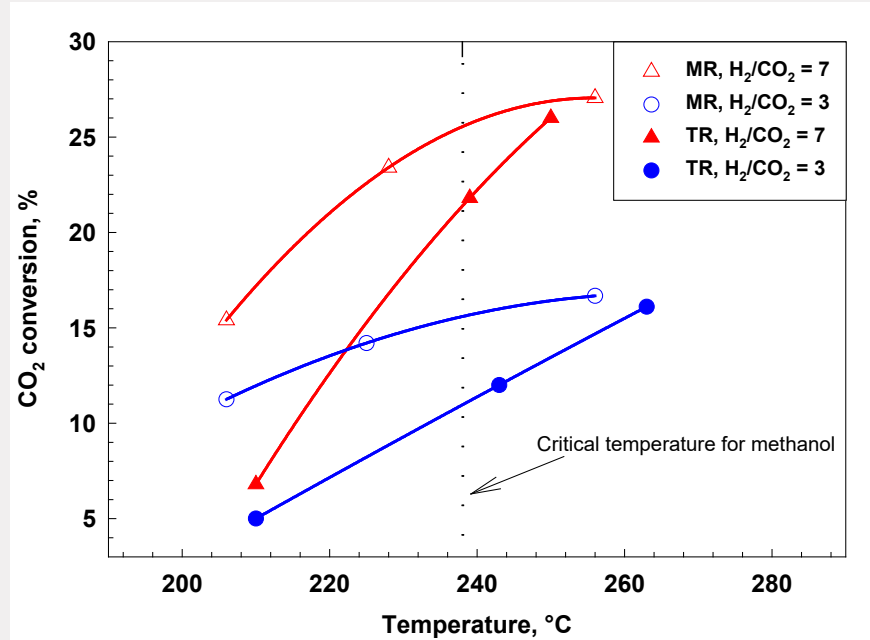
Membranes for methanol

Material

1. Polymeric
2. Zeolites
3. Metallic
4. MOFs
5. 2D

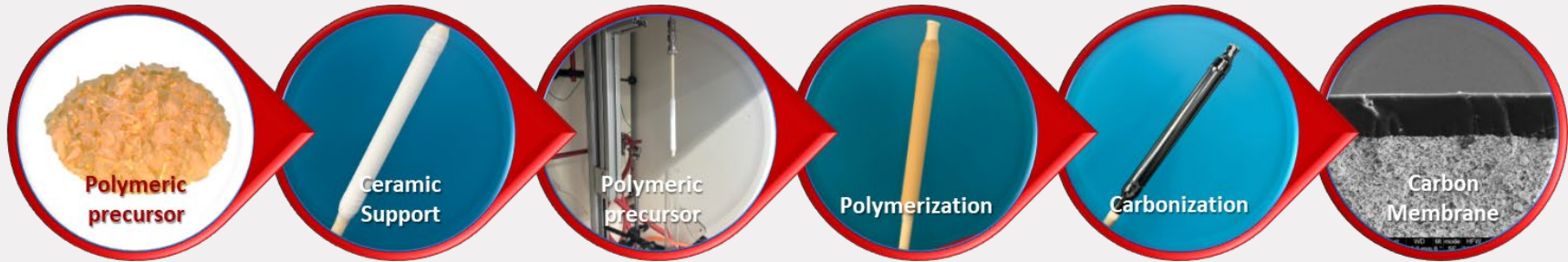


Methanol production in MR

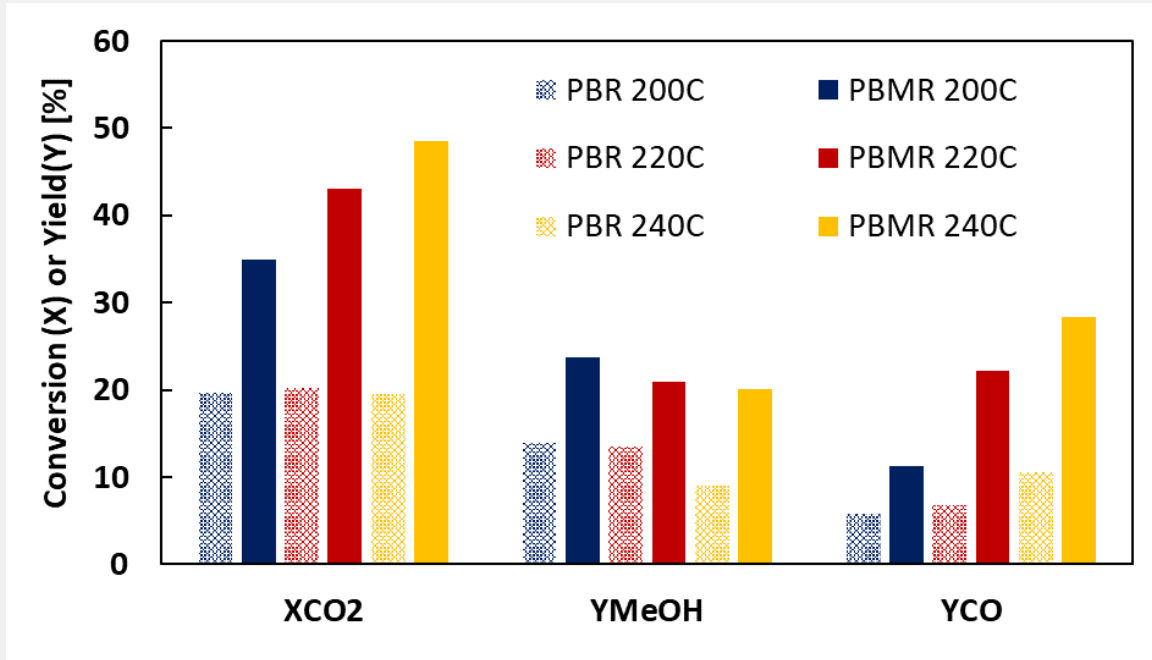


Gallucci et al. *Chemical Engineering and Processing* 2004, 1029-1036

Making CMSMs

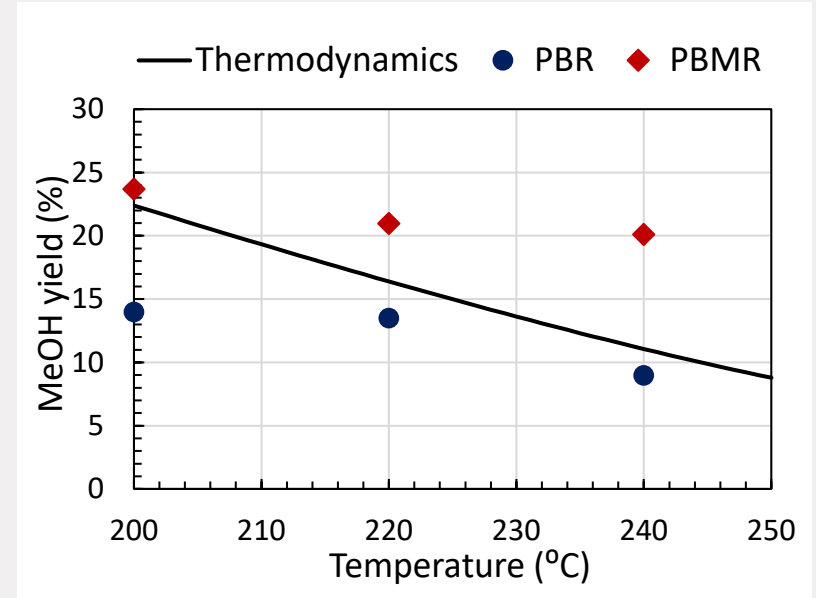
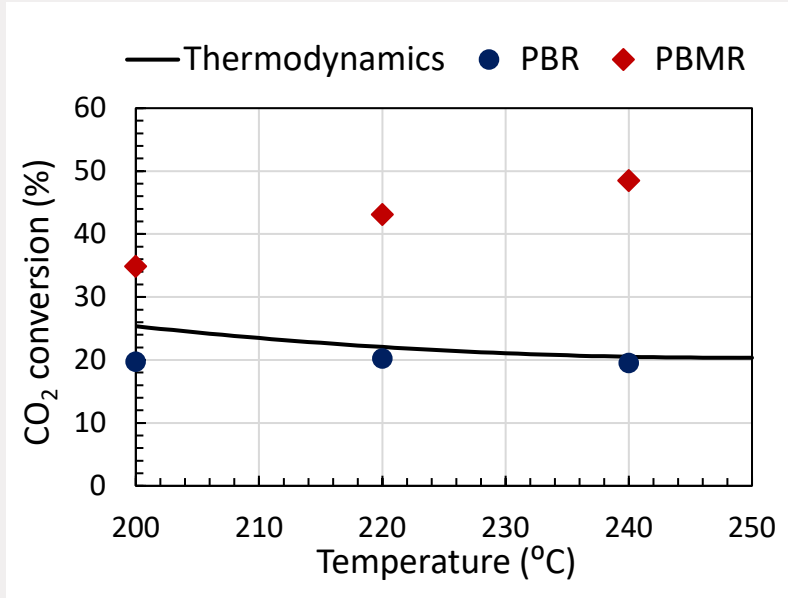


Methanol production in MR



Gallucci et al. *Catalysts* **2026**, *16*(1), 53;

Methanol production in MR

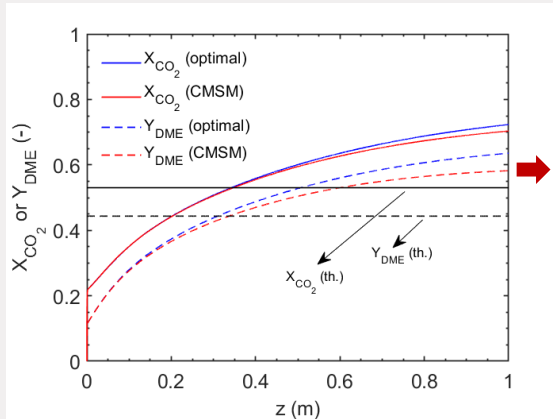


Gallucci et al. *Catalysts* **2026**, *16*(1), 53;

Membrane reactor for DME

Optimal properties vs real carbon membrane properties

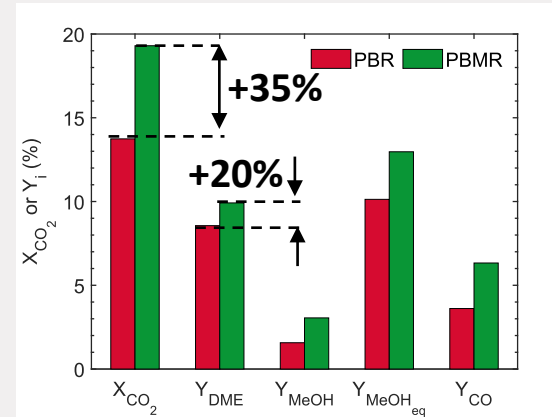
Simulation results³:



Improvement with optimal properties:

$Y_{DME} +36\%$ $X_{CO_2} +43\%$

Experimental results:



3. Poto, Serena, et al. "Direct conversion of CO₂ to dimethyl ether in a fixed bed membrane reactor: Influence of membrane properties and process conditions." *Fuel* 302, 13 p., 121080 (2021)

What's next

- Techno-economics
- Scale up of the membranes up to 50 cm
- Scale-up of systems
- Test in BIO-MeGaFuel conditions



Fausto Gallucci
F.Gallucci@1cube.eu



Fausto Gallucci
F.Gallucci@zefira.tech



Funded by the European Union

