Membrane reactors for (bio)methanol production

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Professor Inorganic Membranes and Membrane Reactors

Outlook

- Who we are
- Why integrated reactors
- CO_2 to methanol
- Next steps

Our Lab(s)

TU/e

tecnalia
MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

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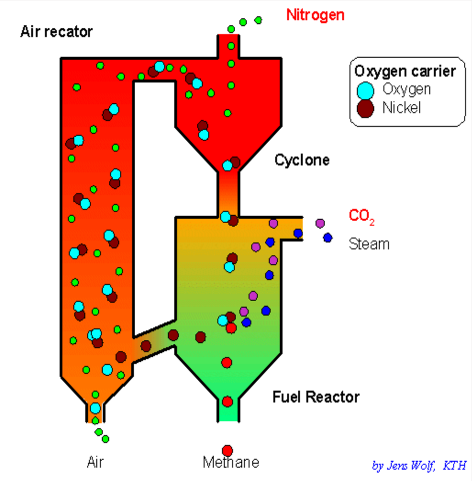
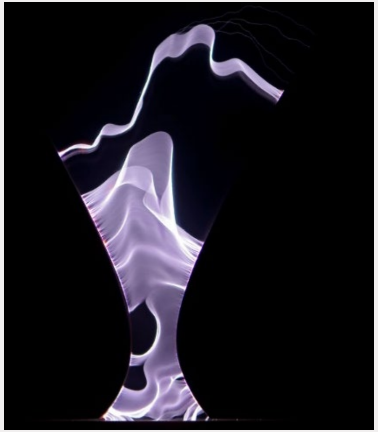
Research themes - SIR

Novel intensified reactor concepts via:

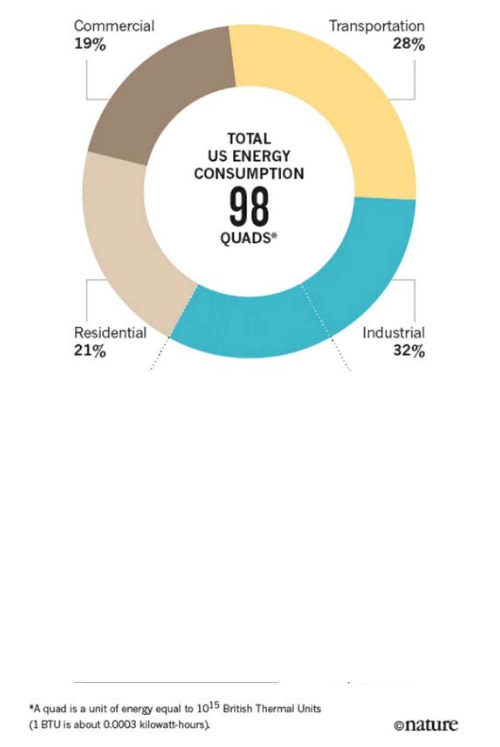
- ➢ Integration reaction and separation (membrane reactors, chemical looping)
- ➢ Integration reaction and heat/energy management (endo/exothermic, plasma systems)

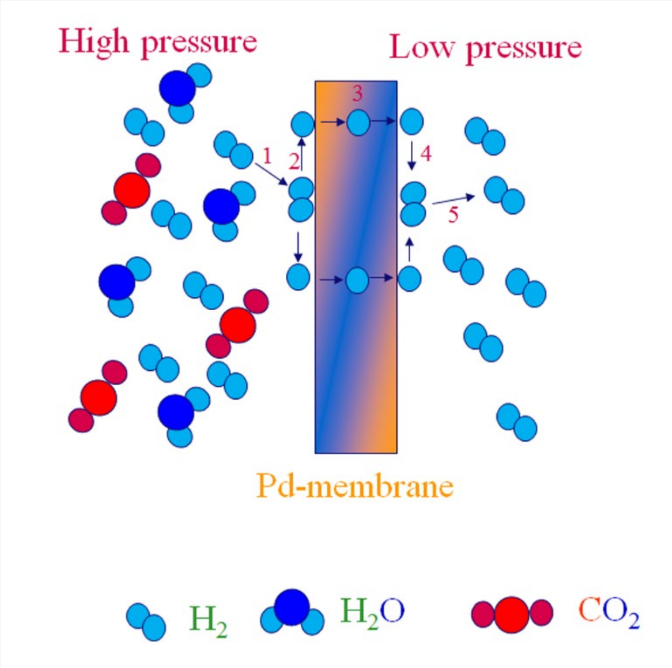




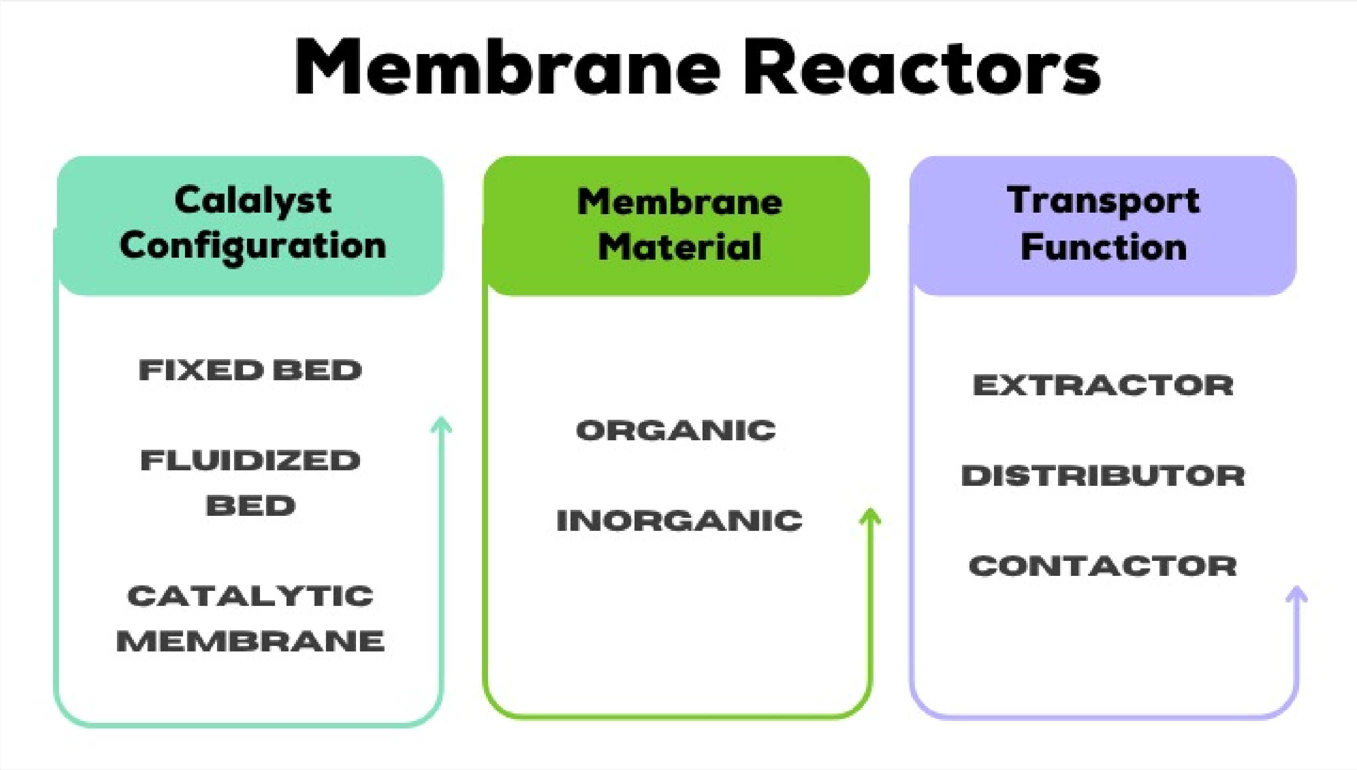
- **Research approach:** combination experimental PoC and modelling

A possible solution

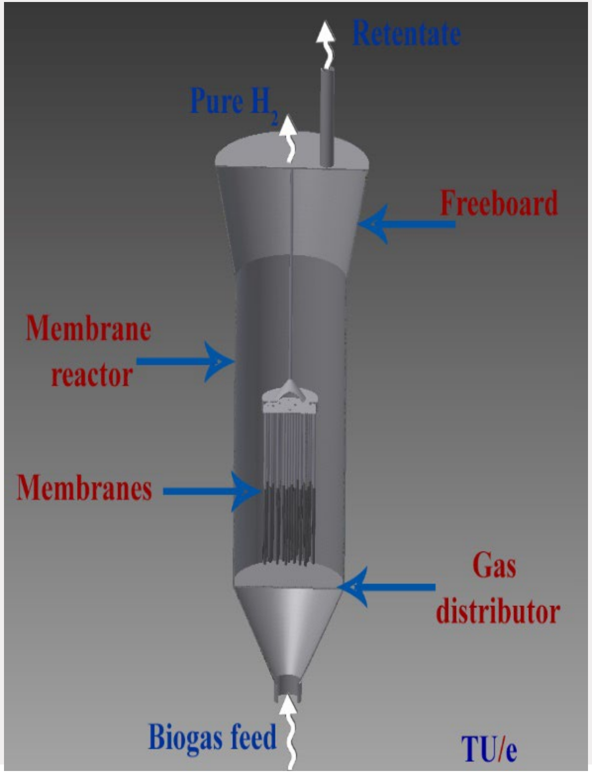


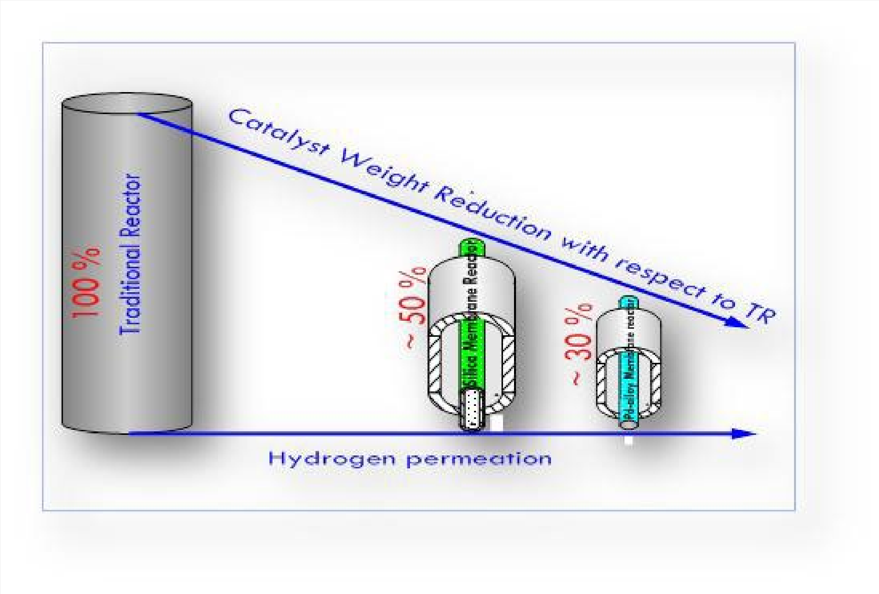


Classification



A membrane reactor

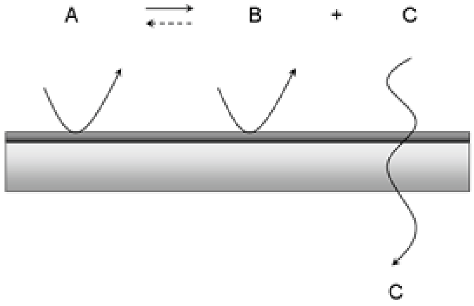


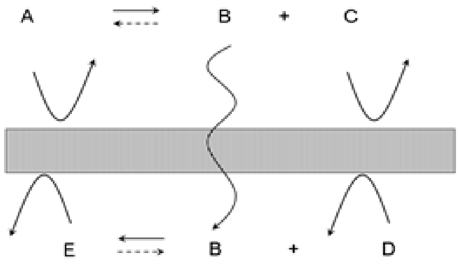


Brunetti A.; Caravella C.; Barbieri G.; Drioli E.; "Simulation study of water gas shift in a membrane reactor", *J. Membr. Sci.*, 2007, 306(1-2), 329-340

Why a membrane reactor?

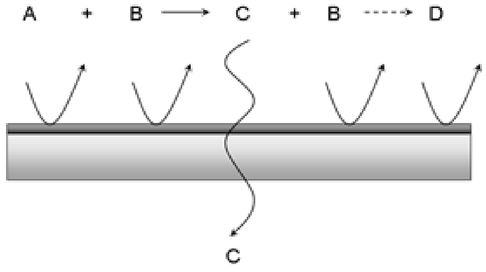
conversion enhancement by selective permeation of a reactant product of an equilibrium limited reaction

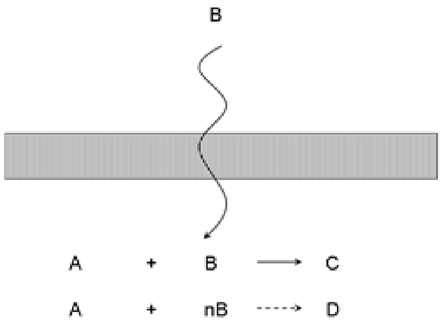




conversion enhancement by coupling of reactions

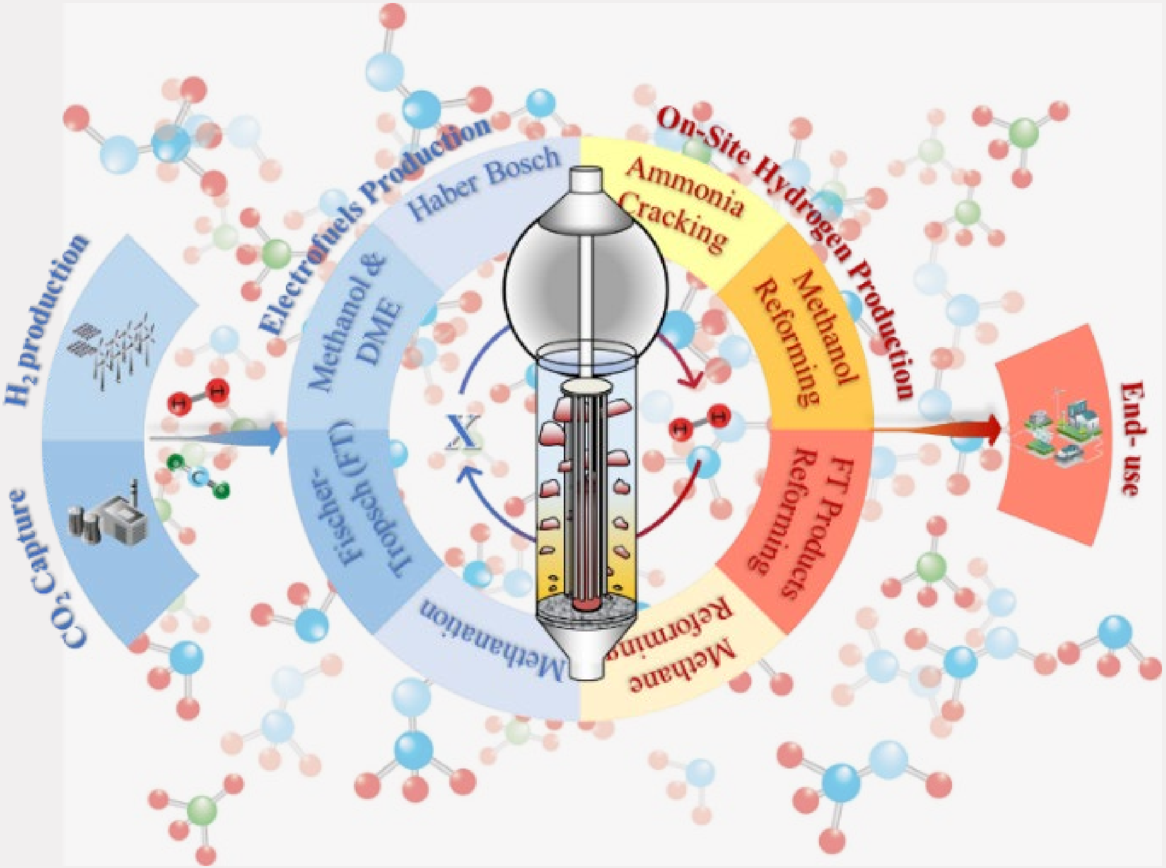
selectivity enhancement by selective permeation of an intermediate product





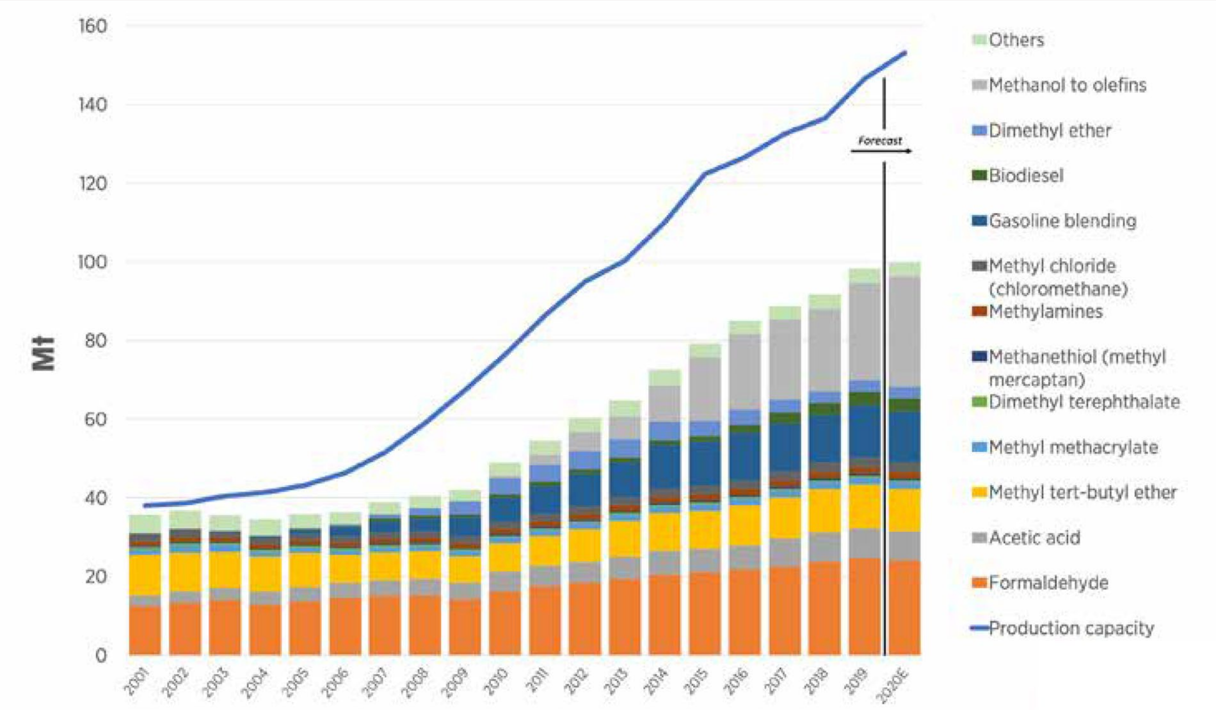
selectivity enhancement by dosing a reactant through the membrane

Use of MR



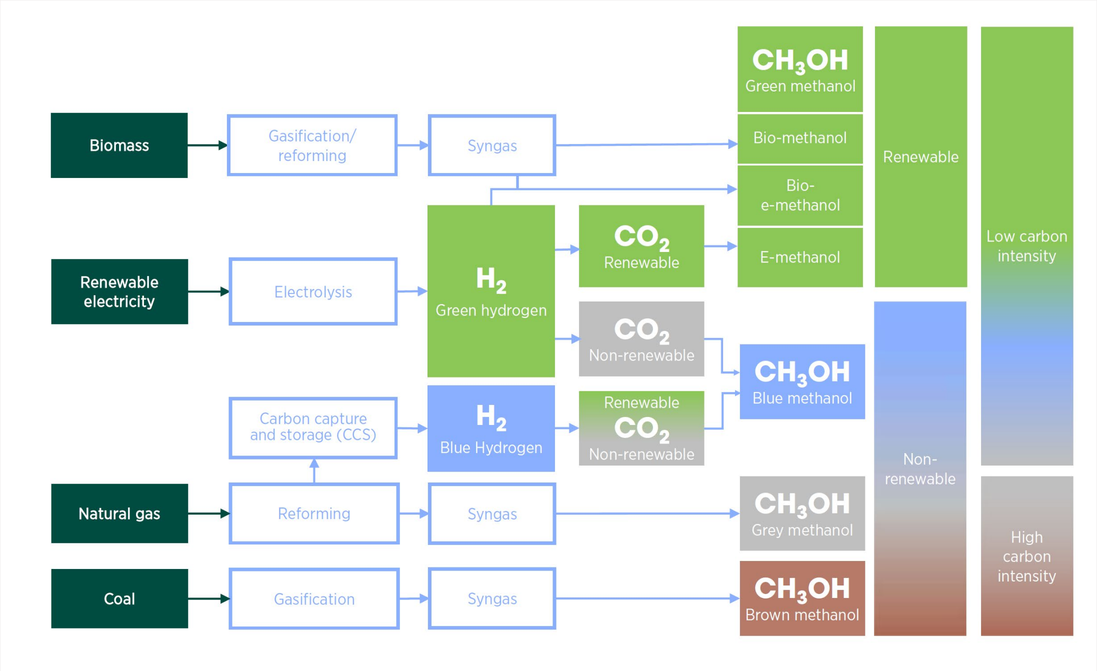
H_2 production
CO_2 Capture
Electrofuels Production
Haber Bosch
Methanol & DME
Fischer-Tropsch (FT)
Methanation
On-Site Hydrogen Production
Ammonia Cracking
Methanol Reforming
FT Products Reforming
Methane Reforming
End- use

Methanol



Global methanol demand and production capacity. Kang, Seungwoo. *Innovation Outlook : Renewable Methanol*; International Renewable Energy Agency, 2021

Methanol



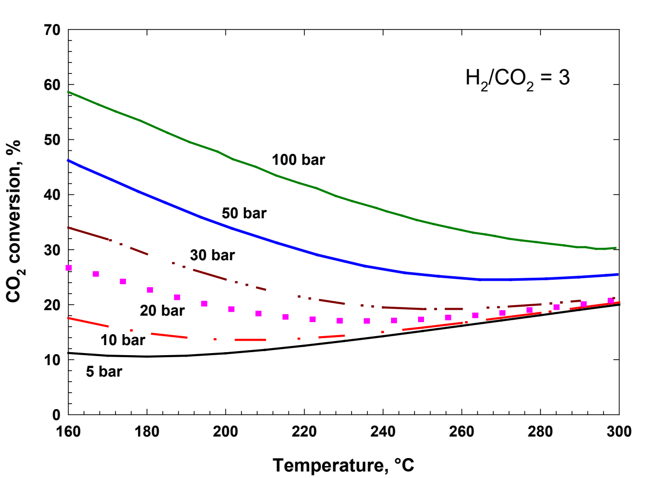
Kang, Seungwoo. *Innovation Outlook : Renewable Methanol*; International Renewable Energy Agency, 2021

Methanol

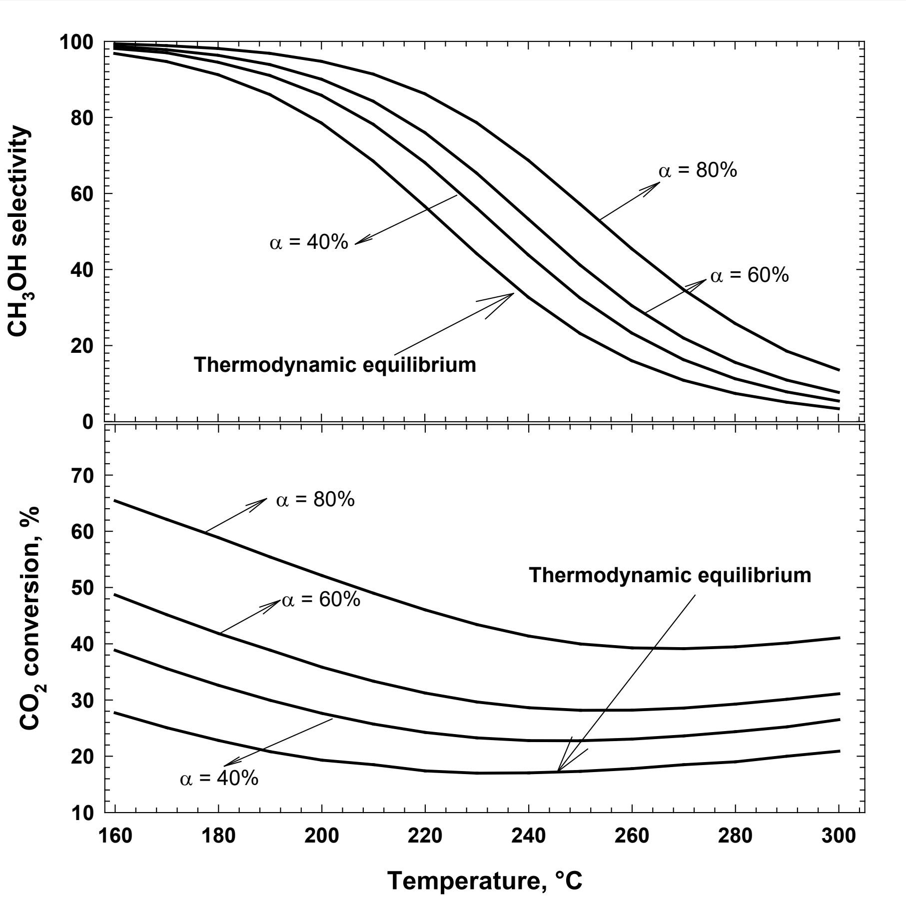
$$CO_2 + 3H_2 \Leftrightarrow CH_3OH + H_2O \qquad \Delta H = -49.5 \text{ kJ/mol}$$

$$CO + 2H_2 \Leftrightarrow CH_3OH \qquad \Delta H = -90.7 \text{ kJ/mol}$$

$$CO_2 + H_2 \Leftrightarrow CO + H_2O \qquad \Delta H = +41.2 \text{ kJ/mol}$$



Methanol

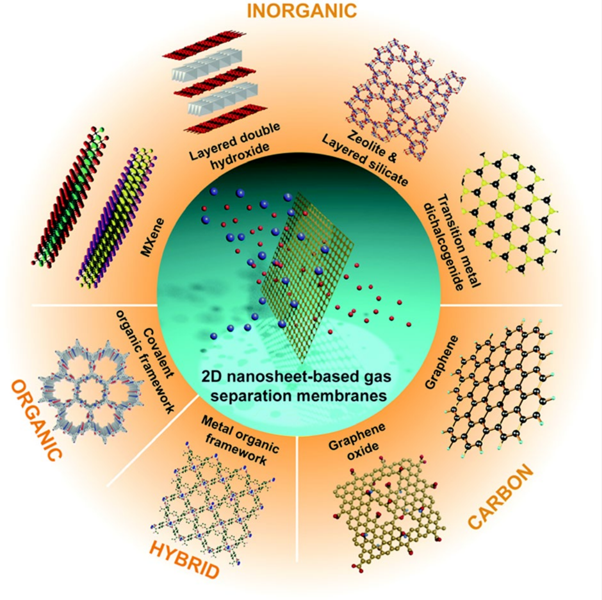


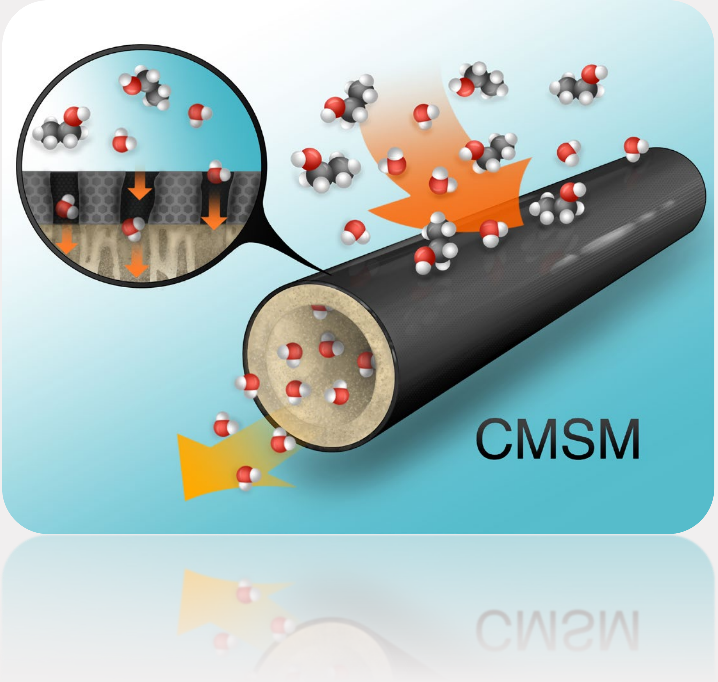
100
80
60
40
20
0
CH_3OH selectivity
α = 80%
α = 40%
α = 60%
Thermodynamic equilibrium
70
60
50
40
30
20
10
CO_2 conversion, %
α = 80%
α = 60%
Thermodynamic equilibrium
α = 40%
160
180
200
220
240
260
280
300
Temperature, °C

Membranes for methanol

Material

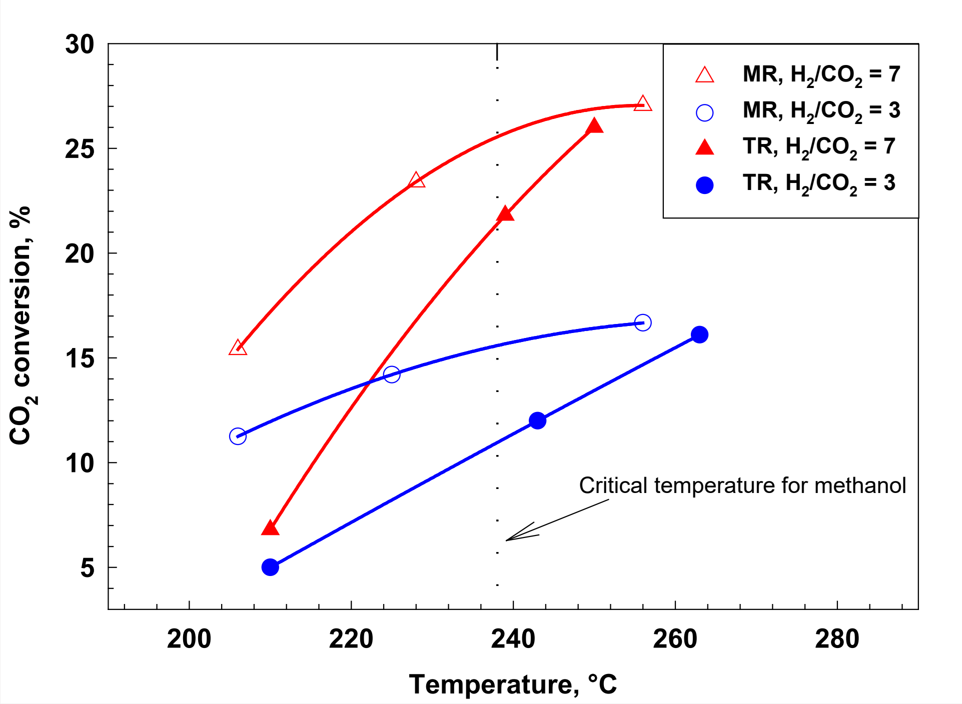
1. Polymeric
2. Zeolites
3. Metallic
4. MOFs
5. 2D



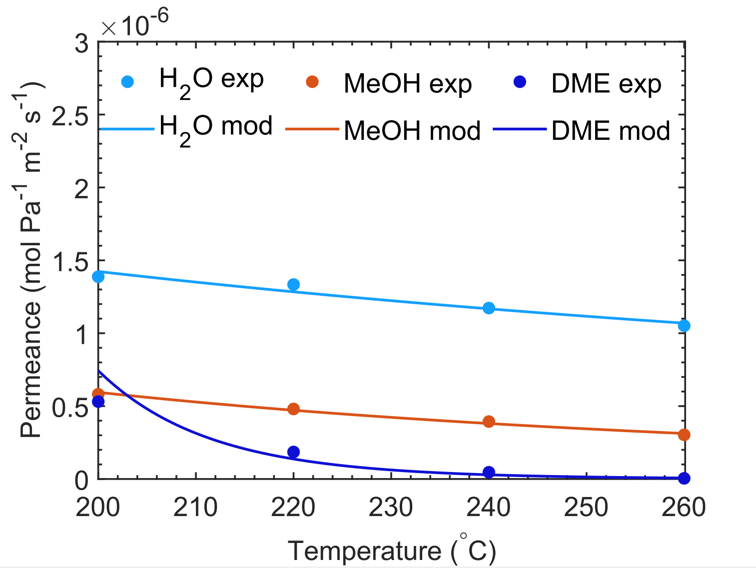


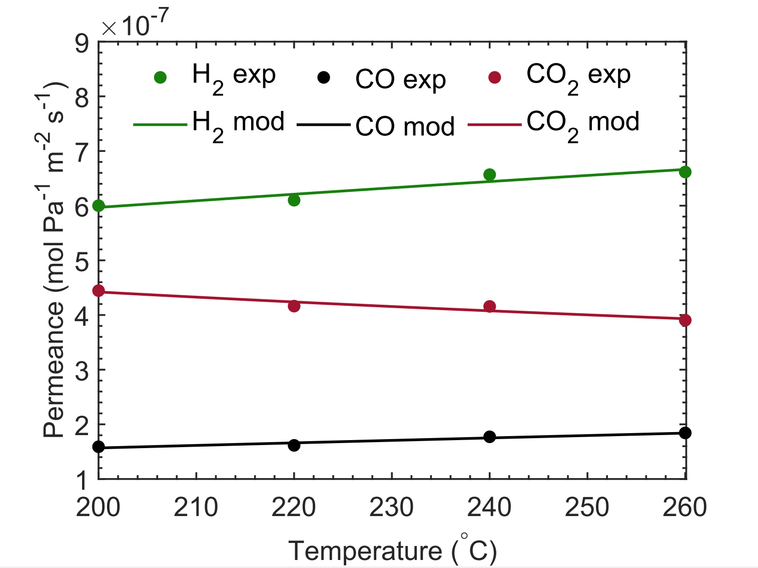
CUBE

Methanol production in MR

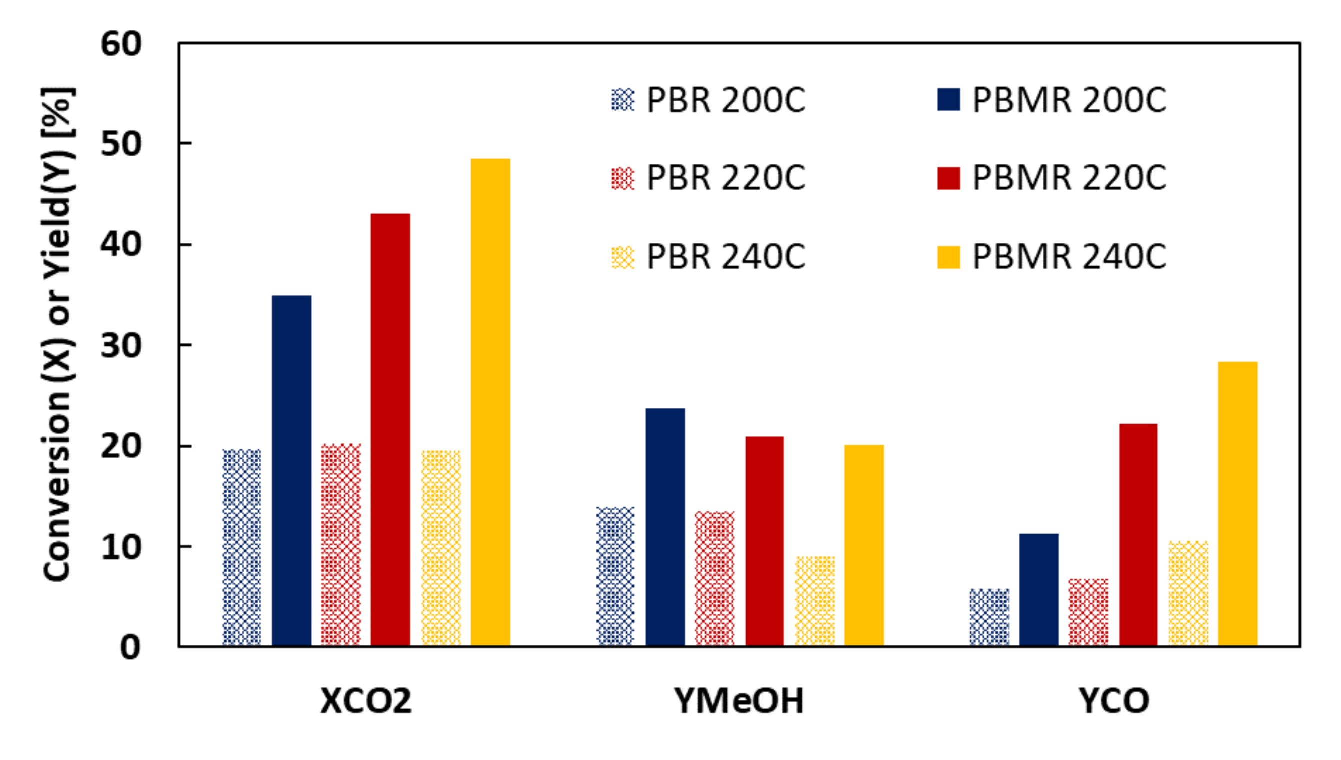


Methanol production in MR

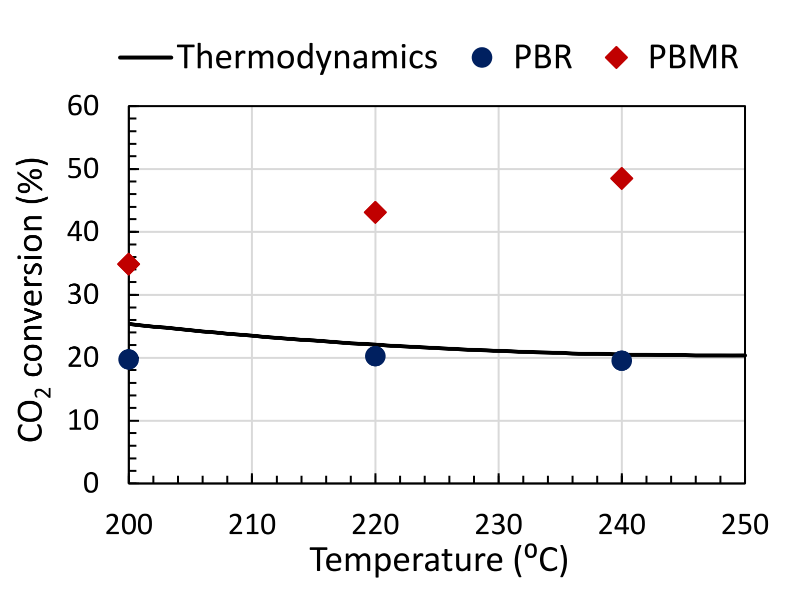


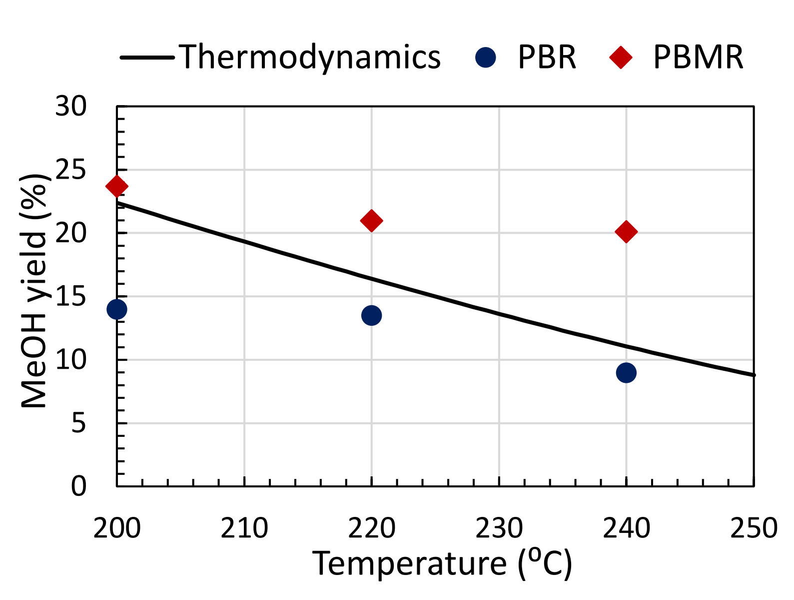


Methanol production in MR



Methanol production in MR

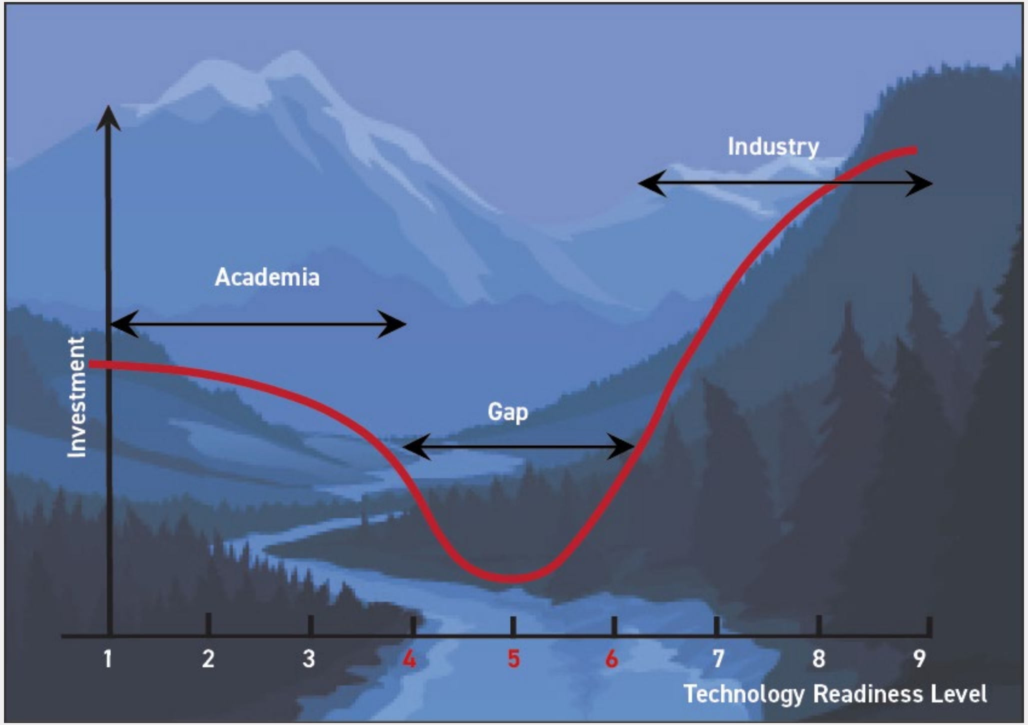




What's next

- Techno-economics
- Detailed design of systems, most probably distributed
- Scale-up of systems

Next steps


Industry
Academia
Gap
Investment
1
2
3
4
5
6
7
8
9
Technology Readiness Level

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