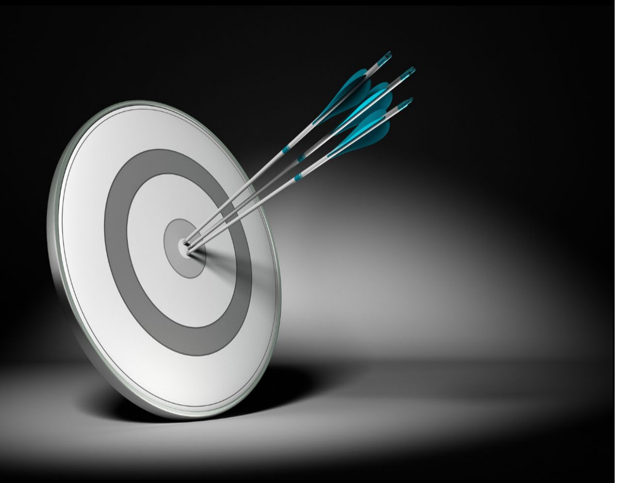
European Innovation Council | Funded by the European Union

Membrane-assisted Ethylene Synthesis over Nanostructured Tandem Catalysts

MEMCAT



Development of water-vapor selective CMSMs for CO_2 valorization using membrane reactors

26th – 29th October 2025

Contact: Claudia Revilla Pacheco
c.a.revilla.pacheco@tue.nl

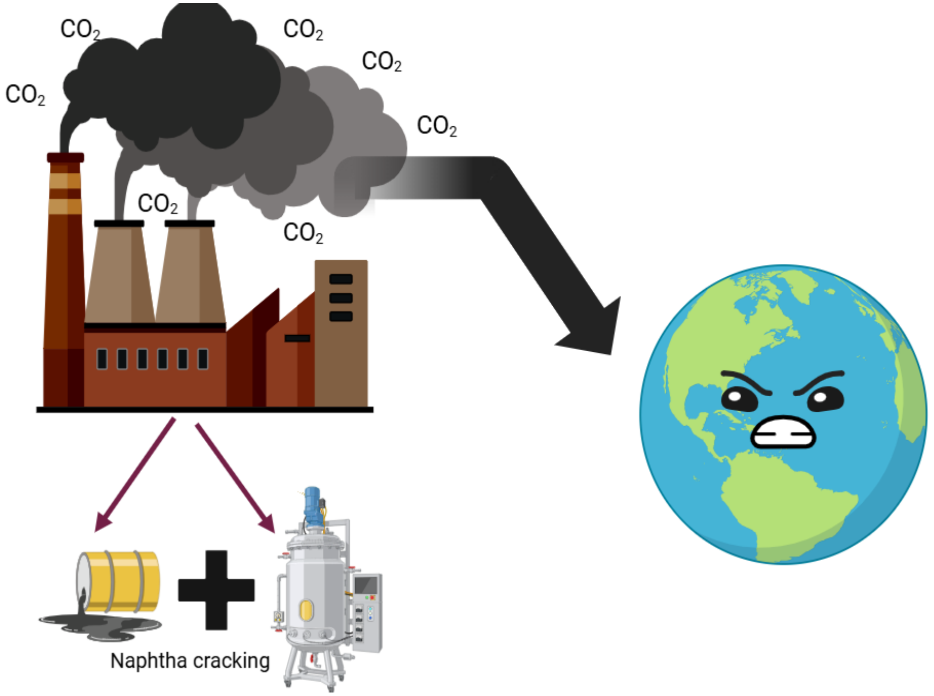
ICCMR 17
26th – 29th October

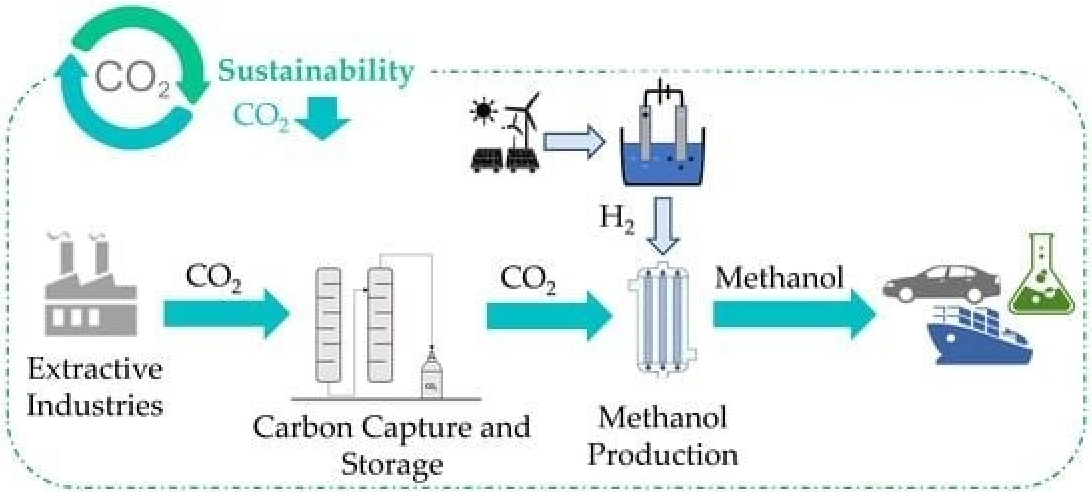
TU/e

European Innovation Council
Funded by the European Union

CO_2 as a feedstock

MEMCAT





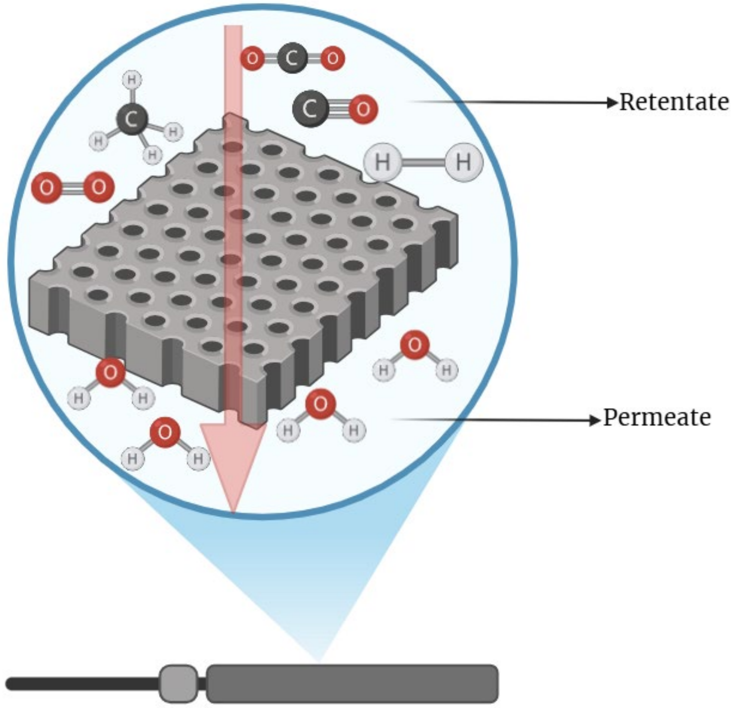
Carbon Capture Utilization[1]

1: Peppas, A., Kottaridis, S., Politi, C., & Angelopoulos, P. M. (2023). Carbon Capture Utilization and Storage in Extractive Industries for Methanol Production. In *Eng* (Vol. 4, Issue 1, pp. 480–506). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/eng4010029

TU/e

Carbon membranes

Advanta-ges	Easy to manufacture
	Offer molecular sieve separation effect
	High permeance
	Work in conditions where polymeric membranes are not stable



European Innovation Council
Funded by the European Union

Nanofillers

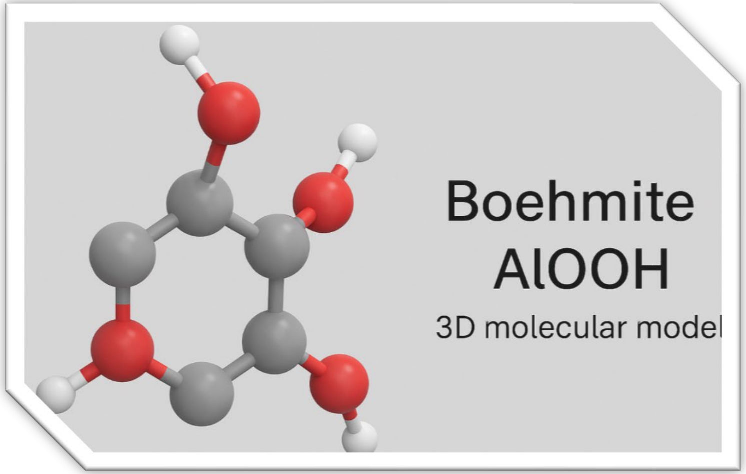
MEMCAT

- Permeance
- Selectivity
- Stability

Hydrophilic surface

Adsorption sites

Layered structure

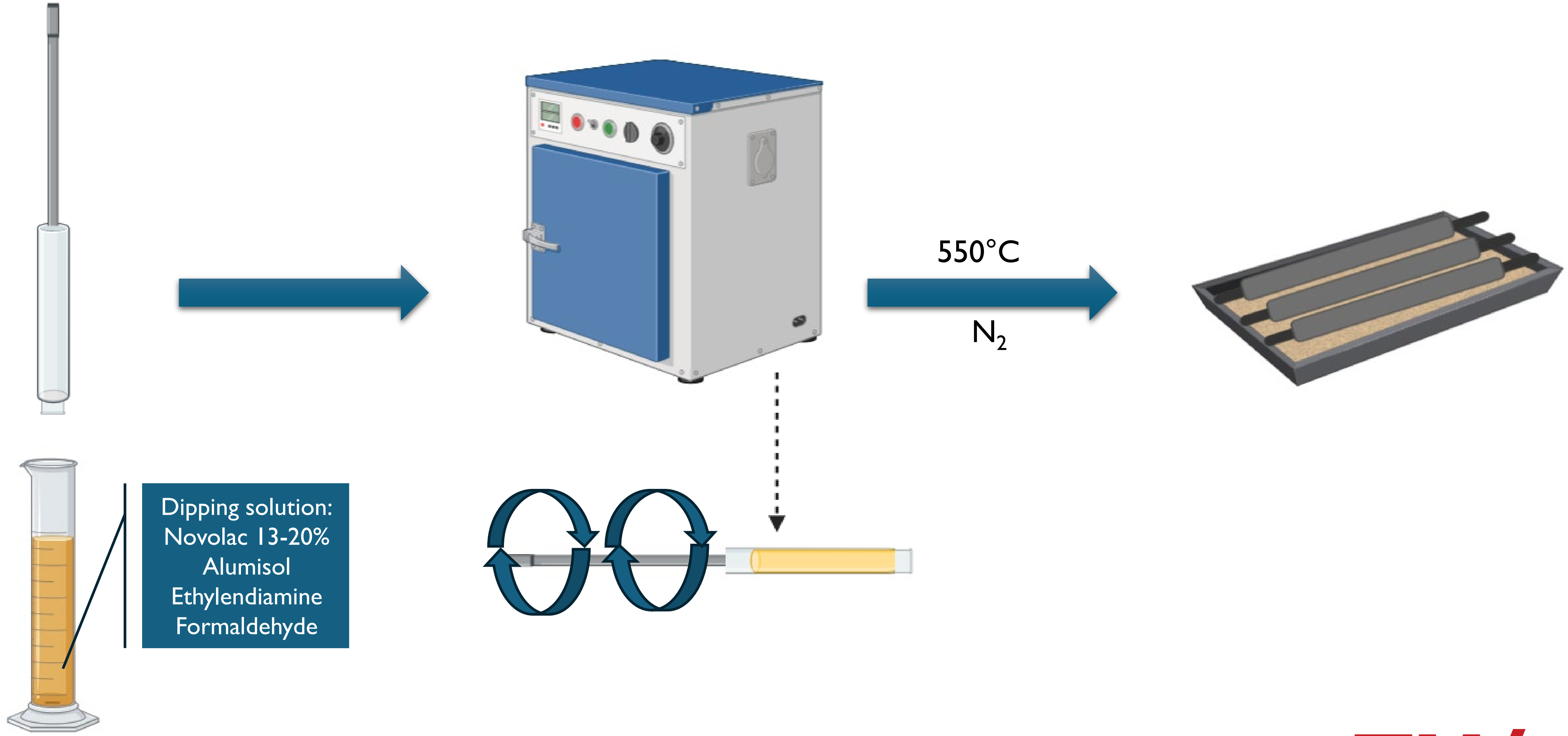


TU/e

European Innovation Council | Funded by the European Union

Membrane fabrication

MEMCAT

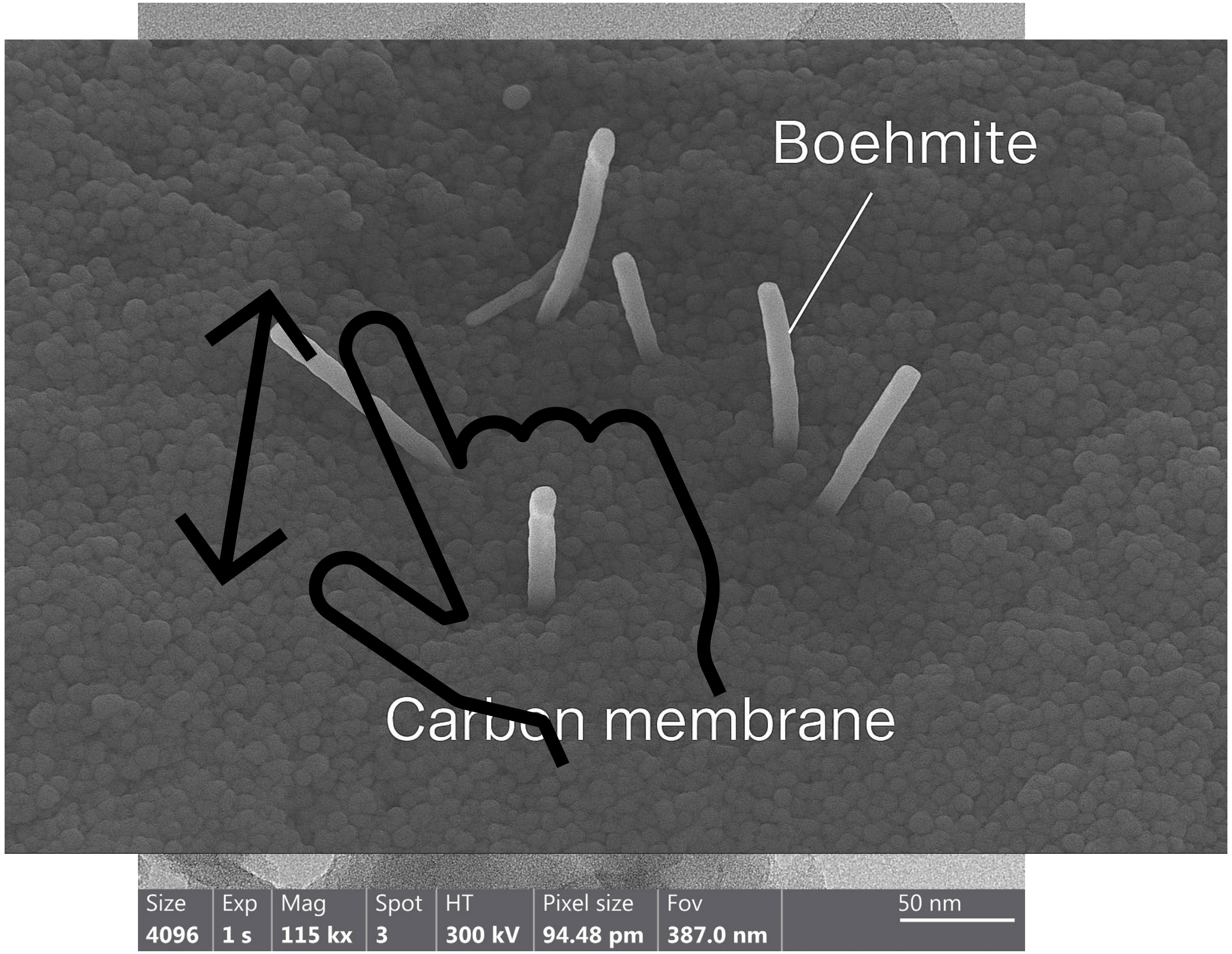


TU/e

European Innovation Council
Funded by the European Union

TEM

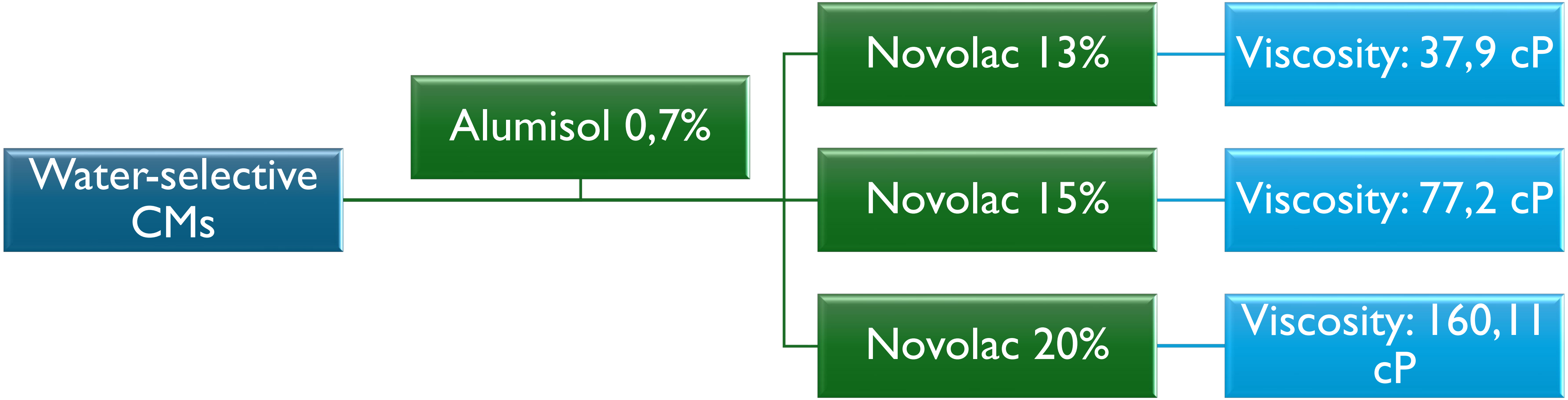
MEMCAT



TU/e

European Innovation Council
Funded by the European Union

MEMCAT



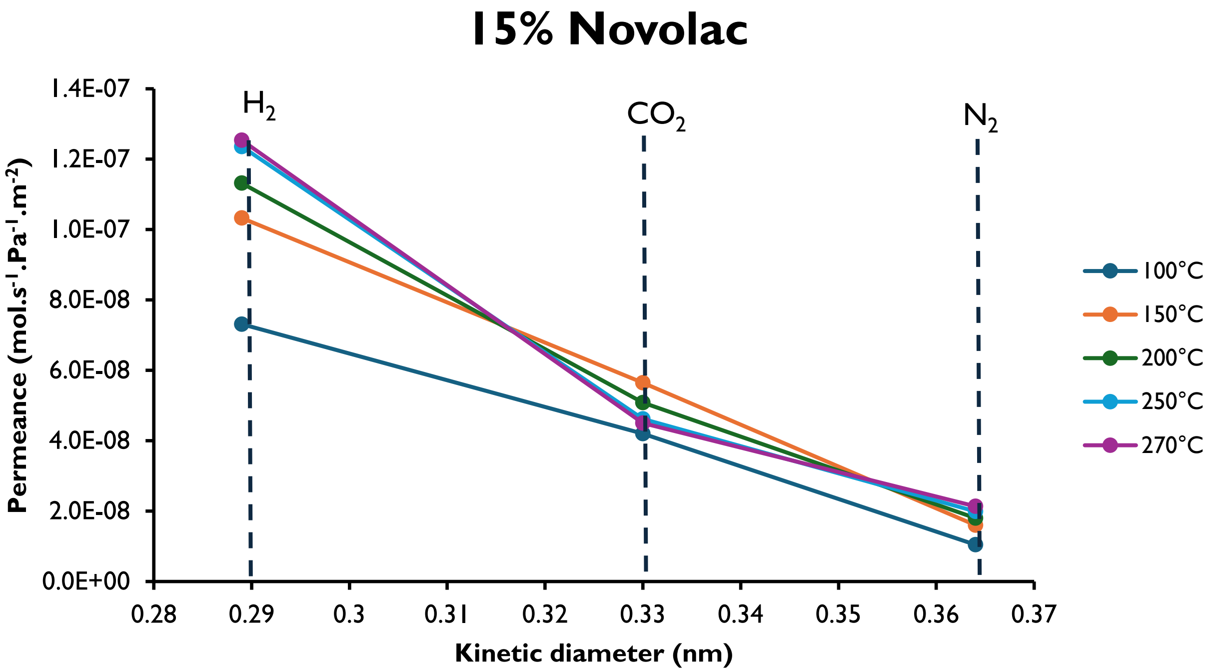
Viscosity directly related to the polymer load

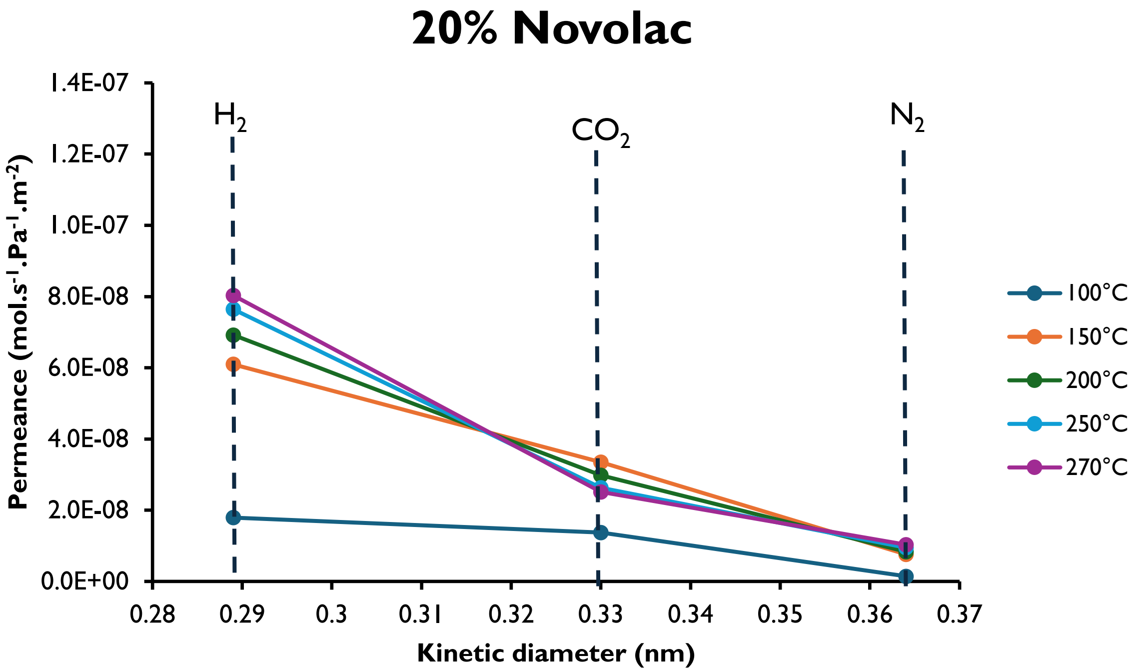
TU/e

European Innovation Council | Funded by the European Union

MEMCAT

Dry gas test
ΔP=3 bar





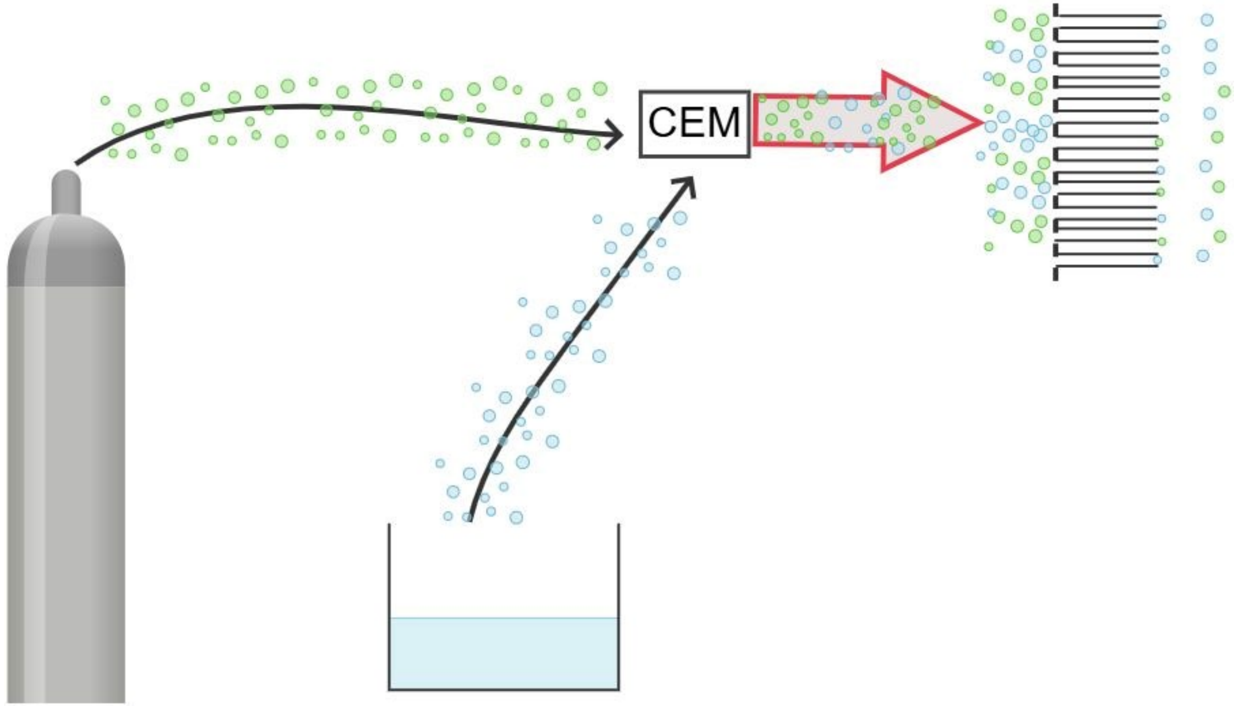
↑ Viscosity improves permeance values

TU/e

European Innovation Council

Funded by the European Union

Binary gas tests



$$\propto_{A/B} = \frac{(y_A/y_B)}{(x_A/x_B)}$$

Equation 1

Where:

$\propto_{A/B}$= separation factor

(x_A/x_B)= mole fraction of components A and B in the feed phase

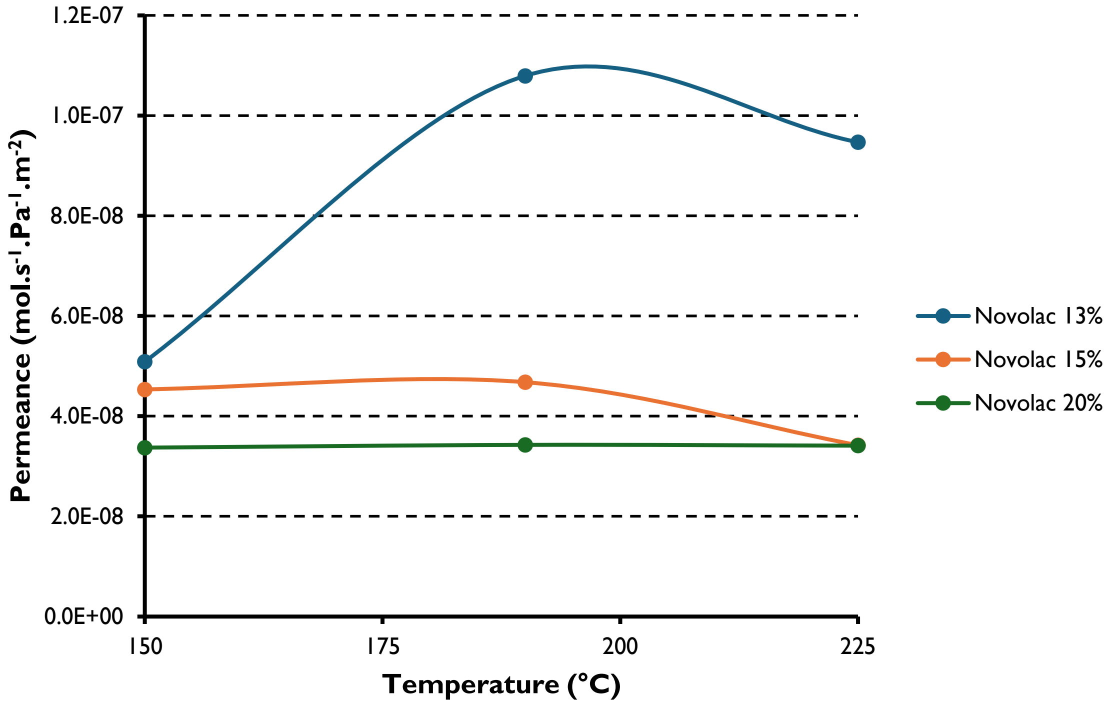
(y_A/y_B)= mole fraction of components A and B in the permeate phase

European Innovation Council

Funded by the European Union

Water permeance

MEMCAT



$$\wp_{H_2O} = \frac{(w_{H_2O,permeated})(M_{w,H_2O}^{-1})}{(\Delta t)(\Delta P_{H_2O})(A_m)}$$ **Equation 2**

Where:
$\wp_{H_2O}$ = water permeance
$w_{H_2O,permeated}$ = weight of water collected from the permeate
M_{w,H_2O}^{-1}= H_2O molecular weight
Δt= time span for water collection
ΔP_{H_2O}= H_2O partial pressure across the membrane
A_m= active surface area

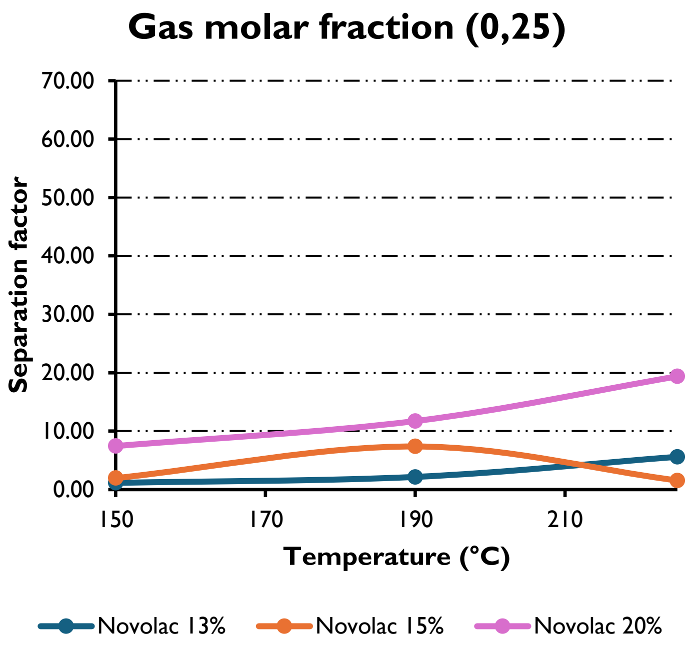
$$\Delta P_{H_2O} = (y_{H_2O,feed})(P_{feed}) - (y_{H_2O,perm})(P_{perm})$$ **Equation 3**

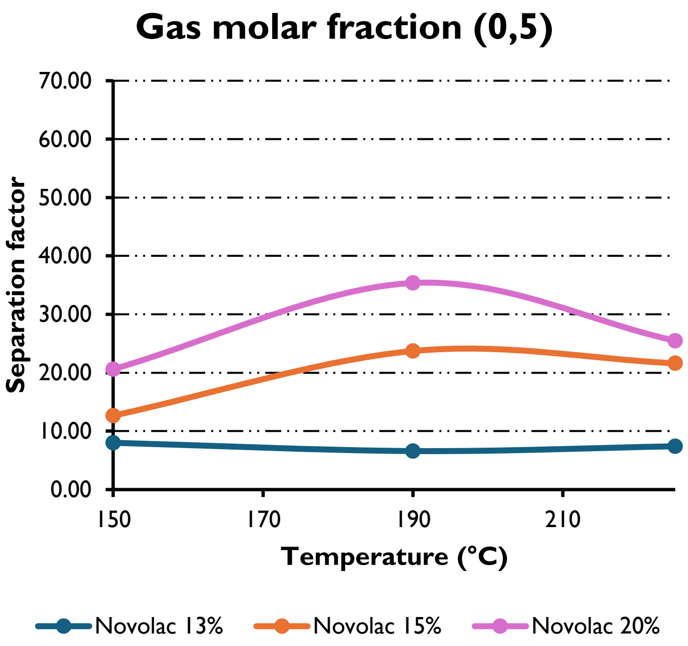
Where:
ΔP_{H_2O}= H_2O partial pressure across the membrane
y_{H_2O}= molar fraction of H_2O
P = pressure

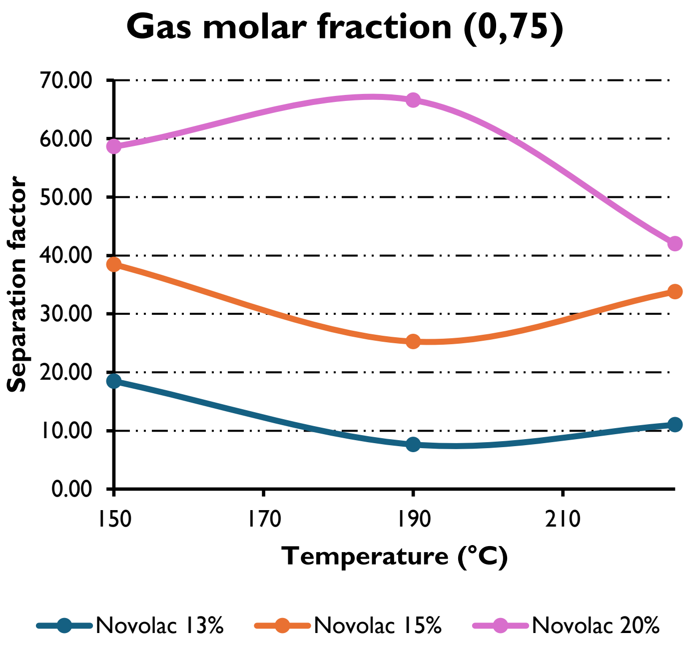
European Innovation Council
Funded by the European Union

H_2O/CO

MEMCAT







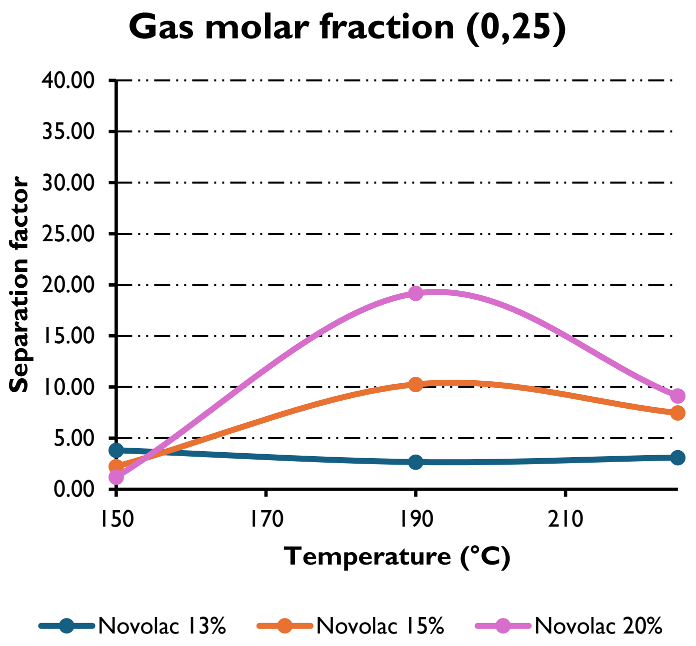
-OH functionalized CMs improves hydrophilicity and H_2O separation trough a dipole-dipole and hydrogen bonding

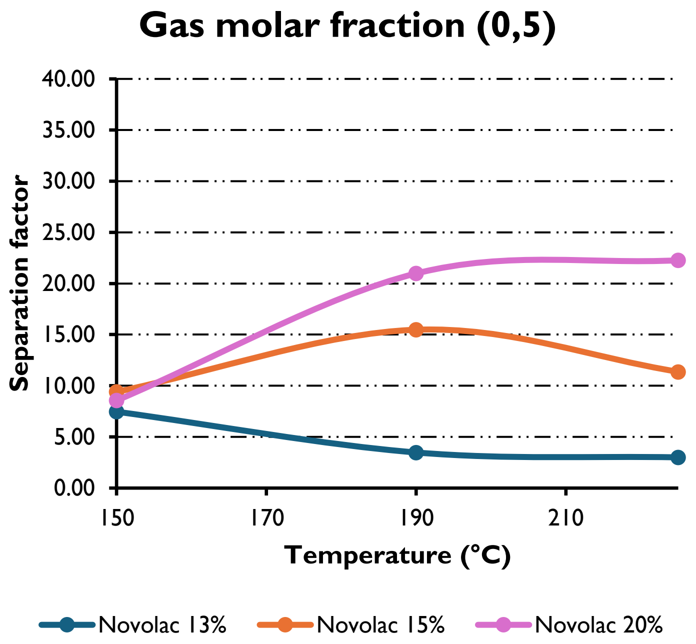
Highly soluble but kinetically trapped on –OH walls

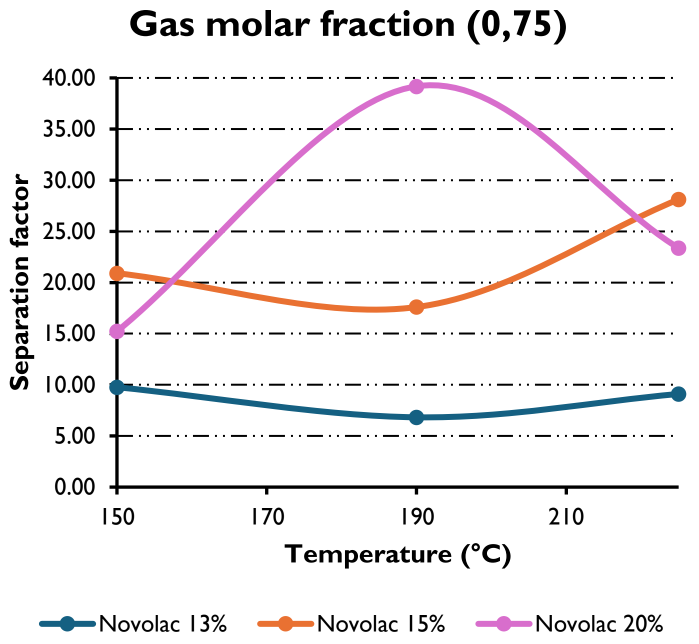
European Innovation Council
Funded by the European Union

H_2O/CO_2

MEMCAT







At higher gas concentration, better separation factor.

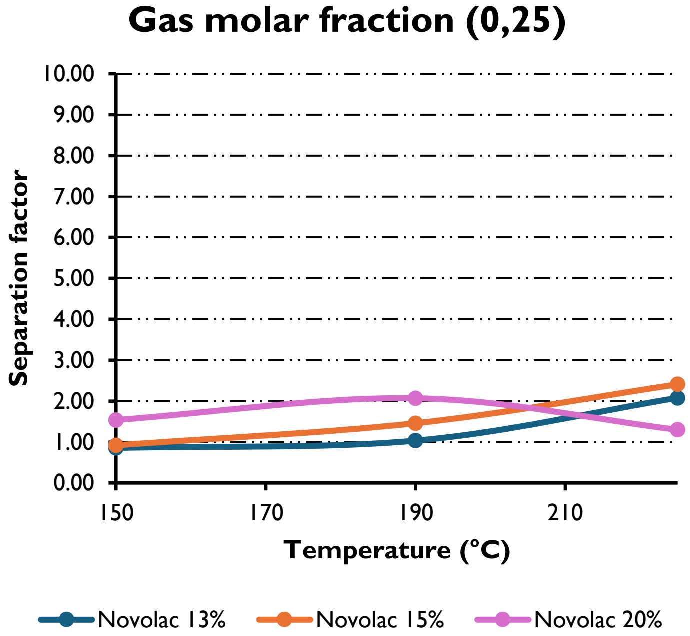
For one dipping, maintain a high viscosity is important

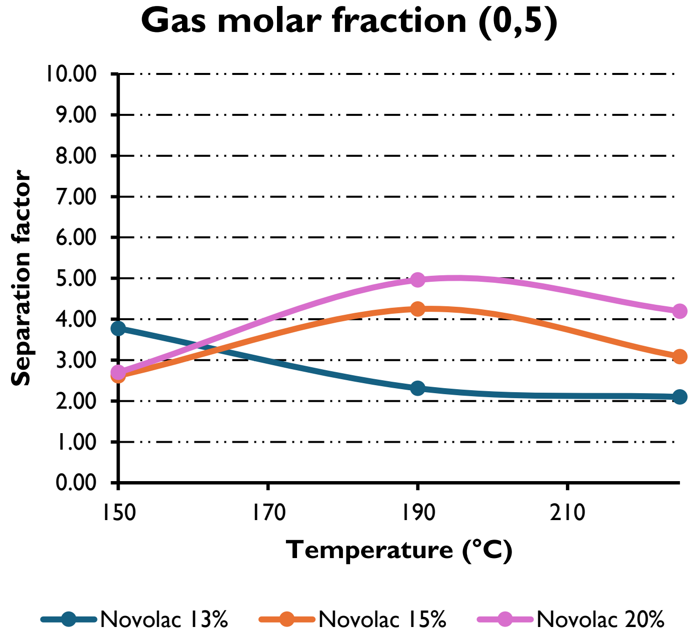
CO_2 adsorption is moderate but diffusivity higher

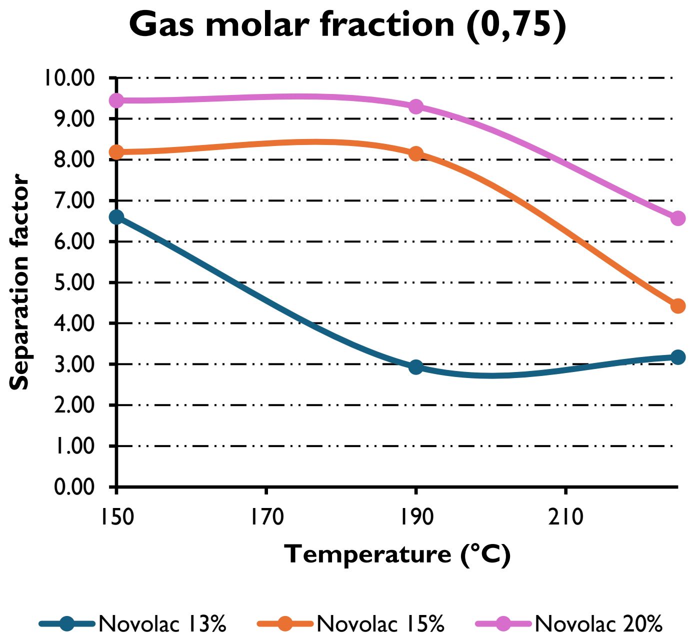
European Innovation Council
Funded by the European Union

H_2O/H_2

MEMCAT







Higher viscosity confers a better SF even at higher temperatures.

→ Higher gas molar fraction helps the H_2O to diffuse into the pores.

TU/e

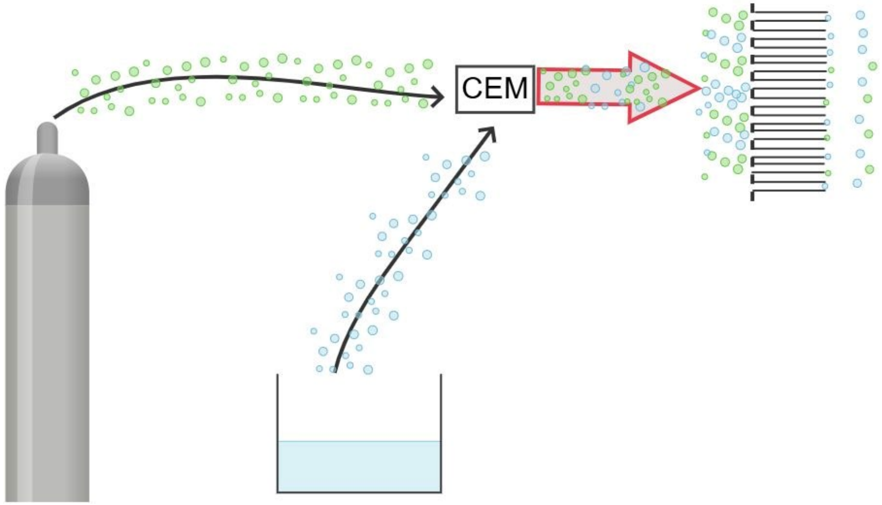
European Innovation Council
Funded by the European Union

Recalling SF calculation

MEMCAT

Equation 1

$$\propto_{A/B} = \frac{(y_A/y_B)}{(x_A/x_B)}$$

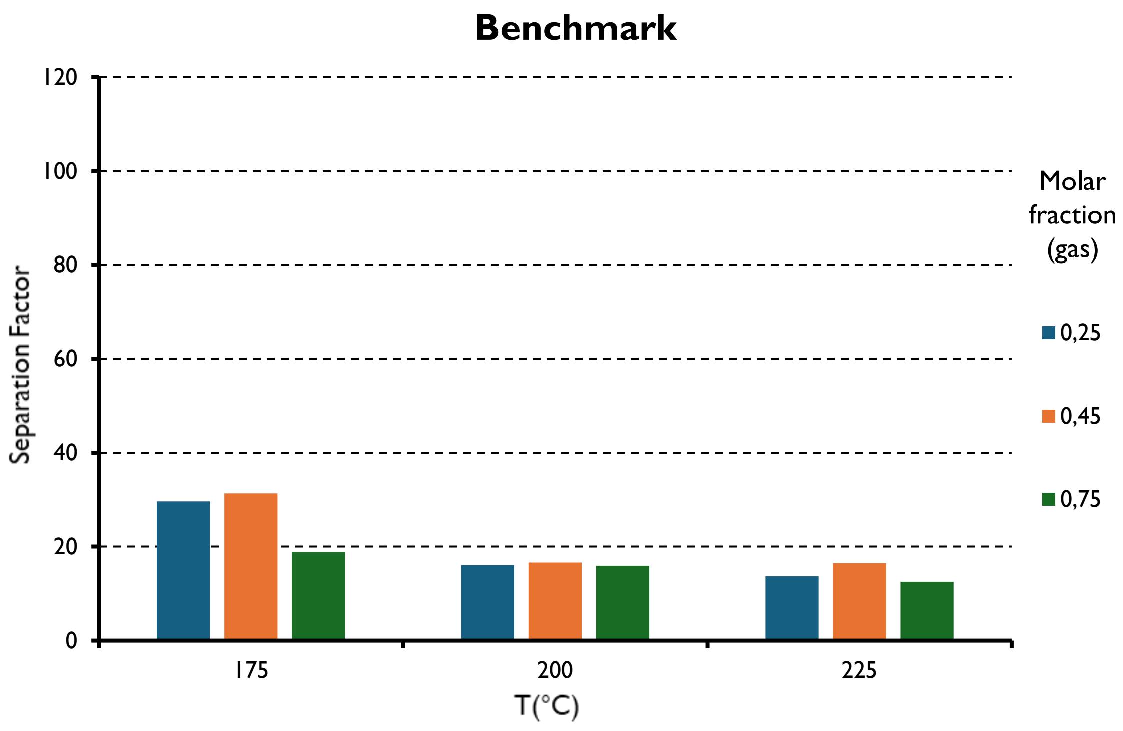


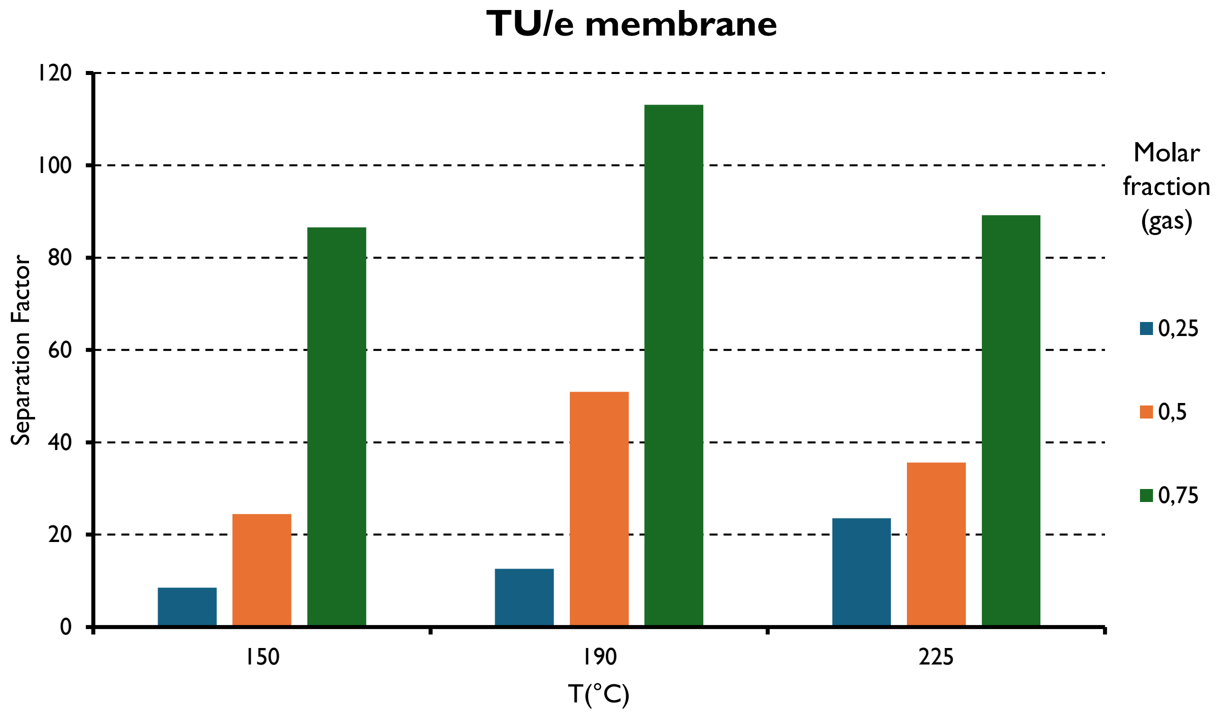
Where:
$\propto_{A/B}$= separation factor
(x_A/x_B)= mole fraction of components A and B in the feed phase
(y_A/y_B)= mole fraction of components A and B in the permeate phase

Where:
$\propto_{A/B}$= separation factor
(x_A/x_B)= mole fraction of components A and B in the retentate phase
(y_A/y_B)= mole fraction of components A and B in the permeate phase

TU/e

Benchmark vs TU/e CM
H_2O/CO

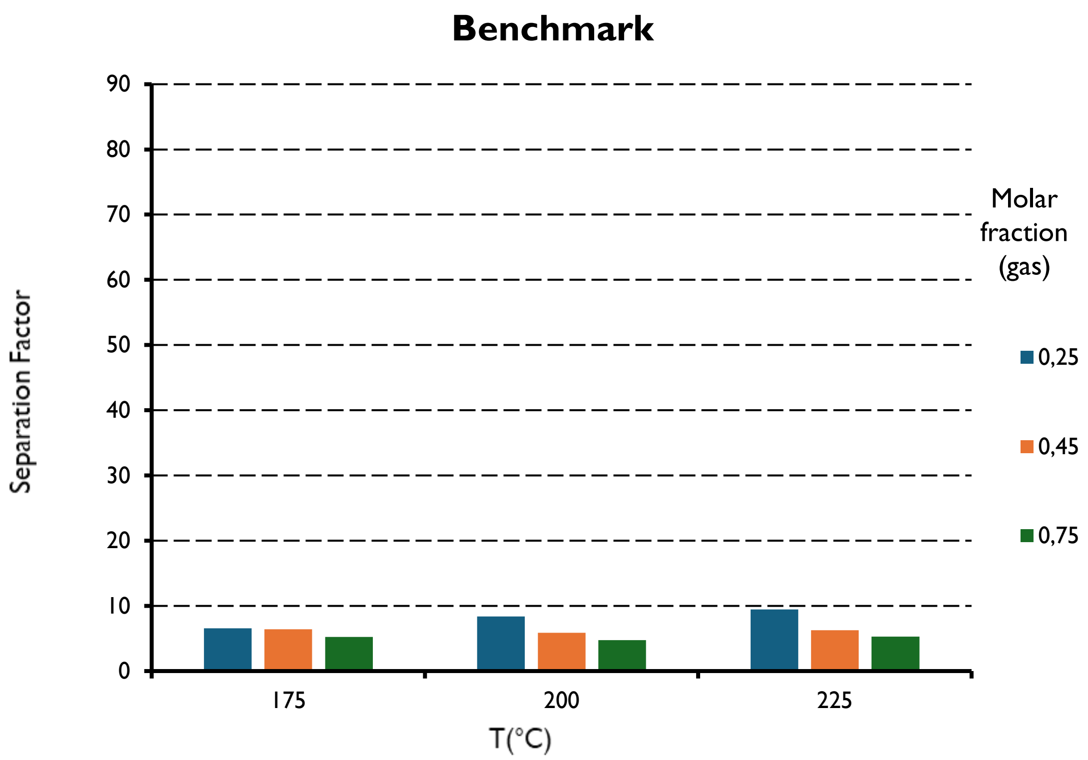


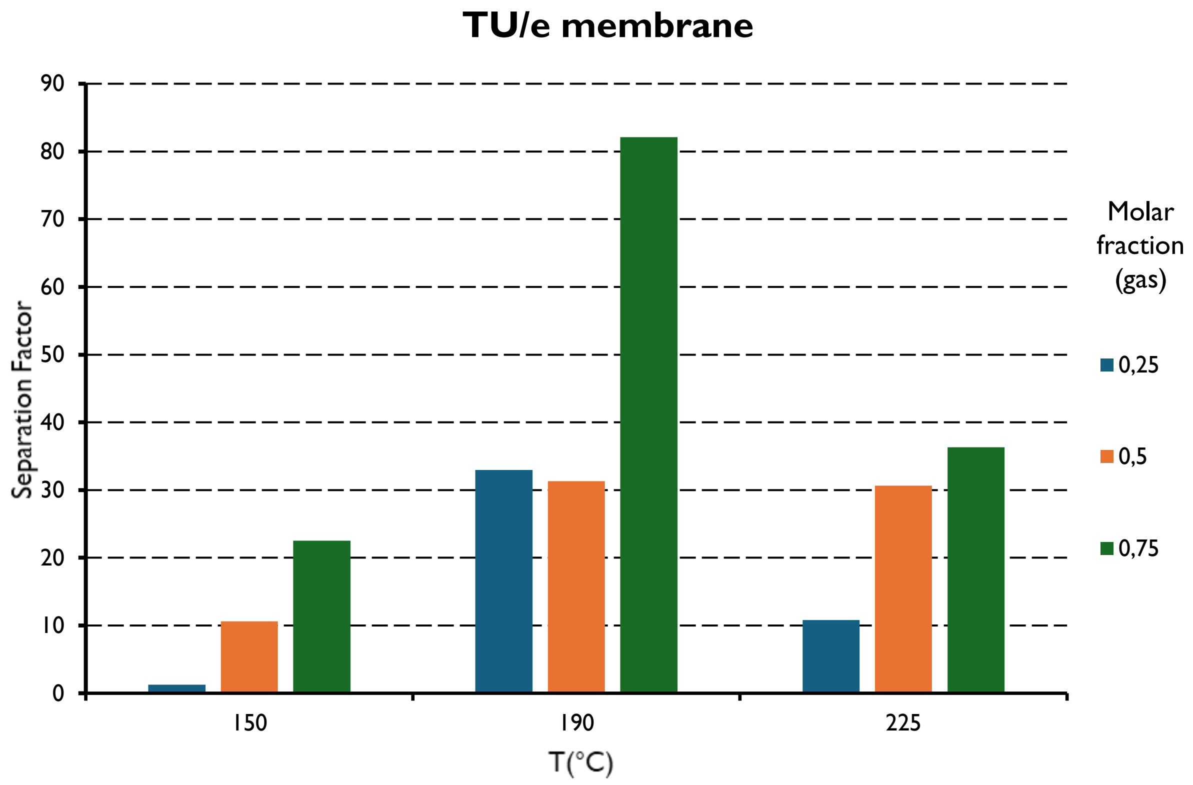


European Innovation Council
Funded by the European Union

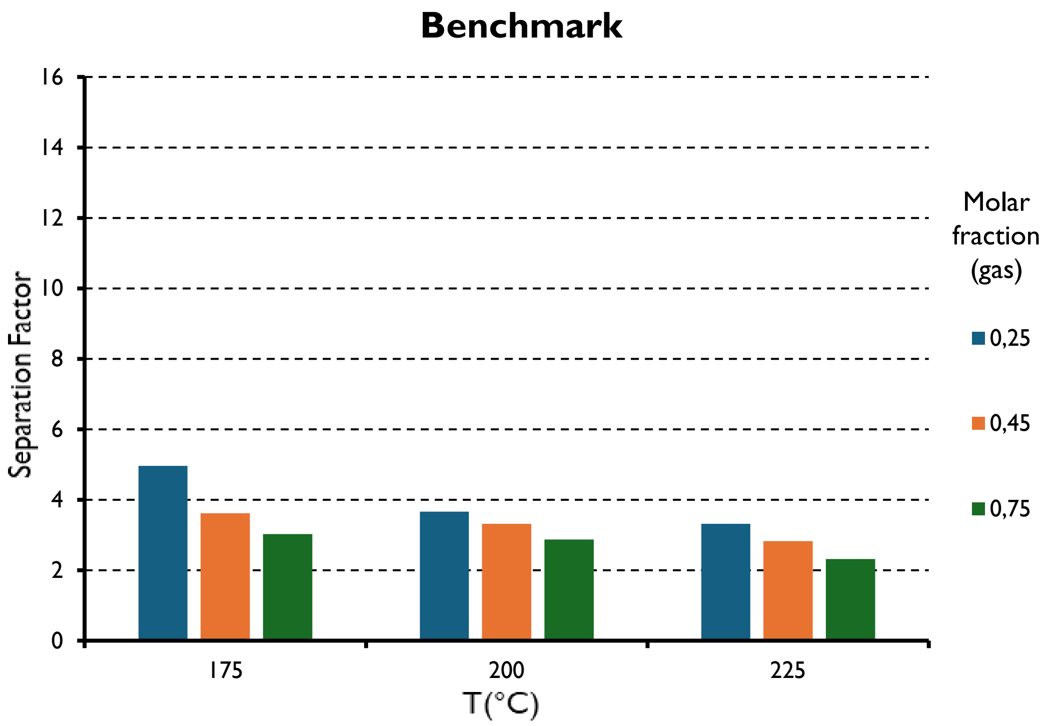
H_2O/CO_2

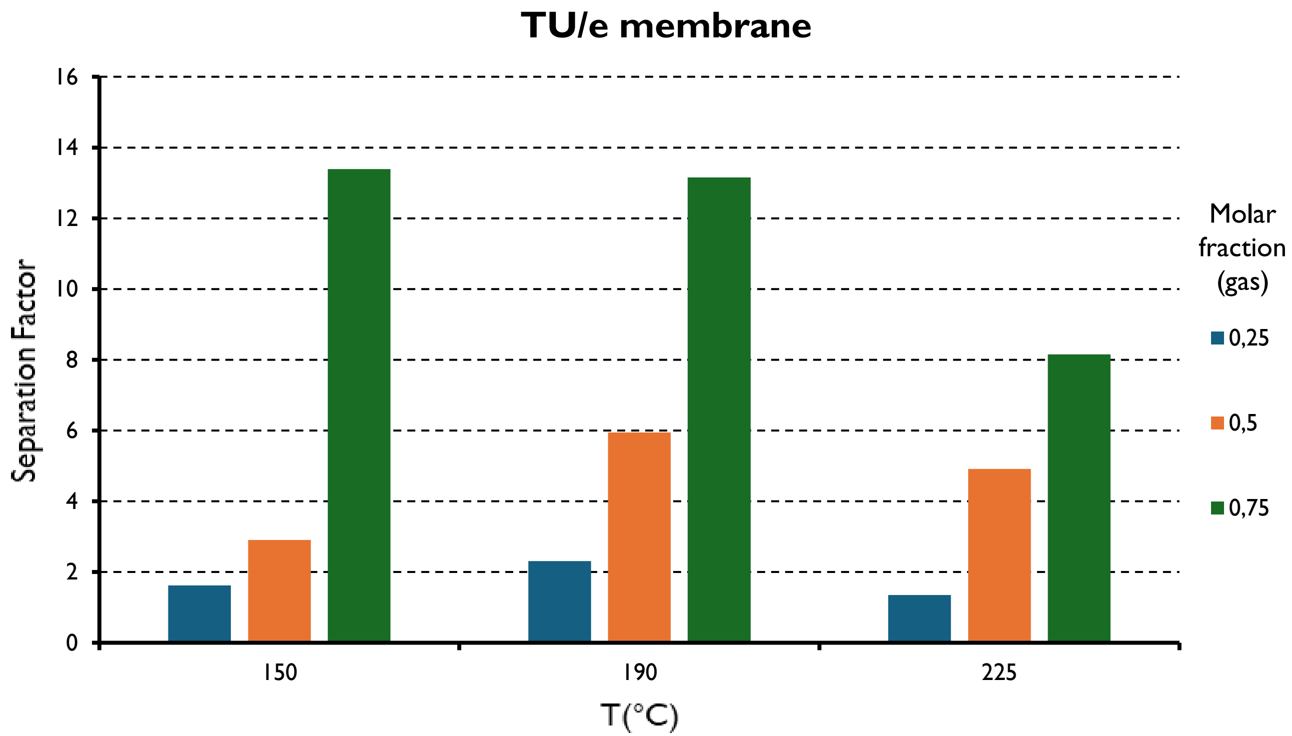
MEMCAT





H_2O/H_2


Benchmark
Separation Factor
16
14
12
10
8
6
4
2
0
175
200
225
T(°C)
Molar fraction (gas)
0,25
0,45
0,75


TU/e membrane
Separation Factor
16
14
12
10
8
6
4
2
0
150
190
225
T(°C)
Molar fraction (gas)
0,25
0,5
0,75

European Innovation Council

Funded by the European Union

Conclusions

MEMCAT

- Increasing the Novolac % improves CM's performance.
- Separation factor deplores for binary gas test at high temperatures (225°C)
- Hydrogen has the lowest separation factor due to its similar kinetic diameter to water.
- Better membrane achieved compared the benchmark.

TU/e

European Innovation Council
Funded by the European Union

Future steps:

- Reproduce best membrane.
- Vary the carbonization temperature
- Permporosimetry studies
- Mixed gas test studies