



Membrane-assisted Ethylene Synthesis over Nanostructured Tandem Catalysts



***Development of water-vapor selective
CMSMs for CO₂ valorization using
membrane reactors***

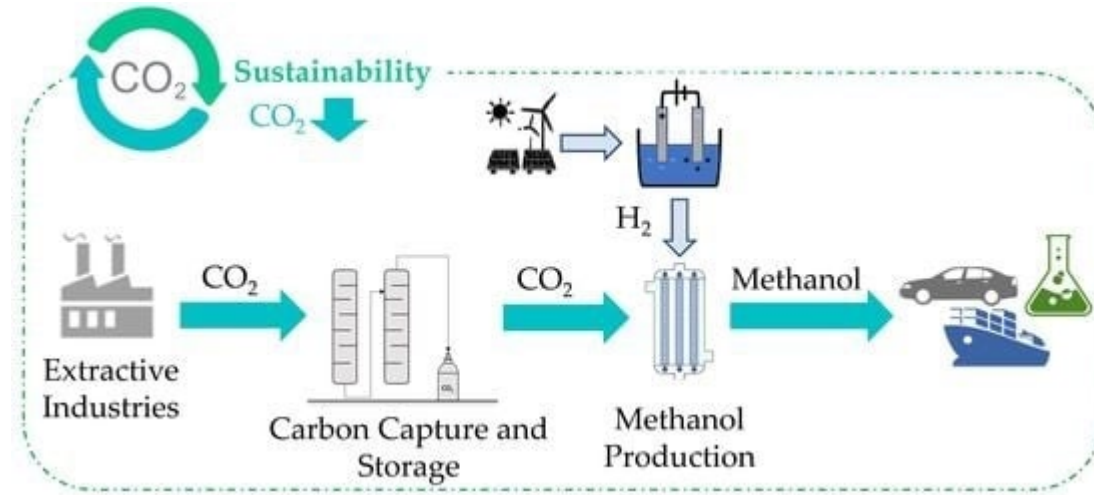
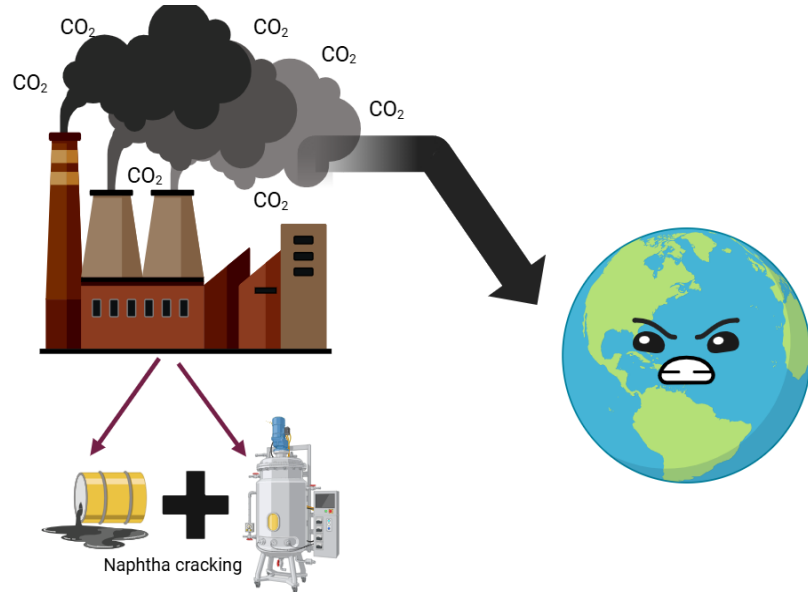
21st – 23rd October 2025

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SEPTech Conference
21st – 23rd October 2025



CO₂ as a feedstock



Carbon Capture Utilization¹

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>

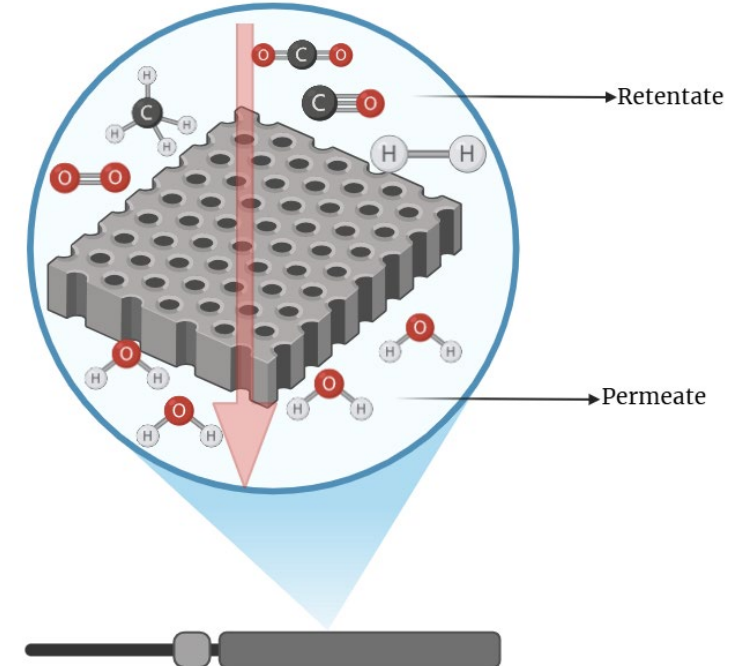
Advantages

Easy to manufacture

Offer molecular sieve separation effect

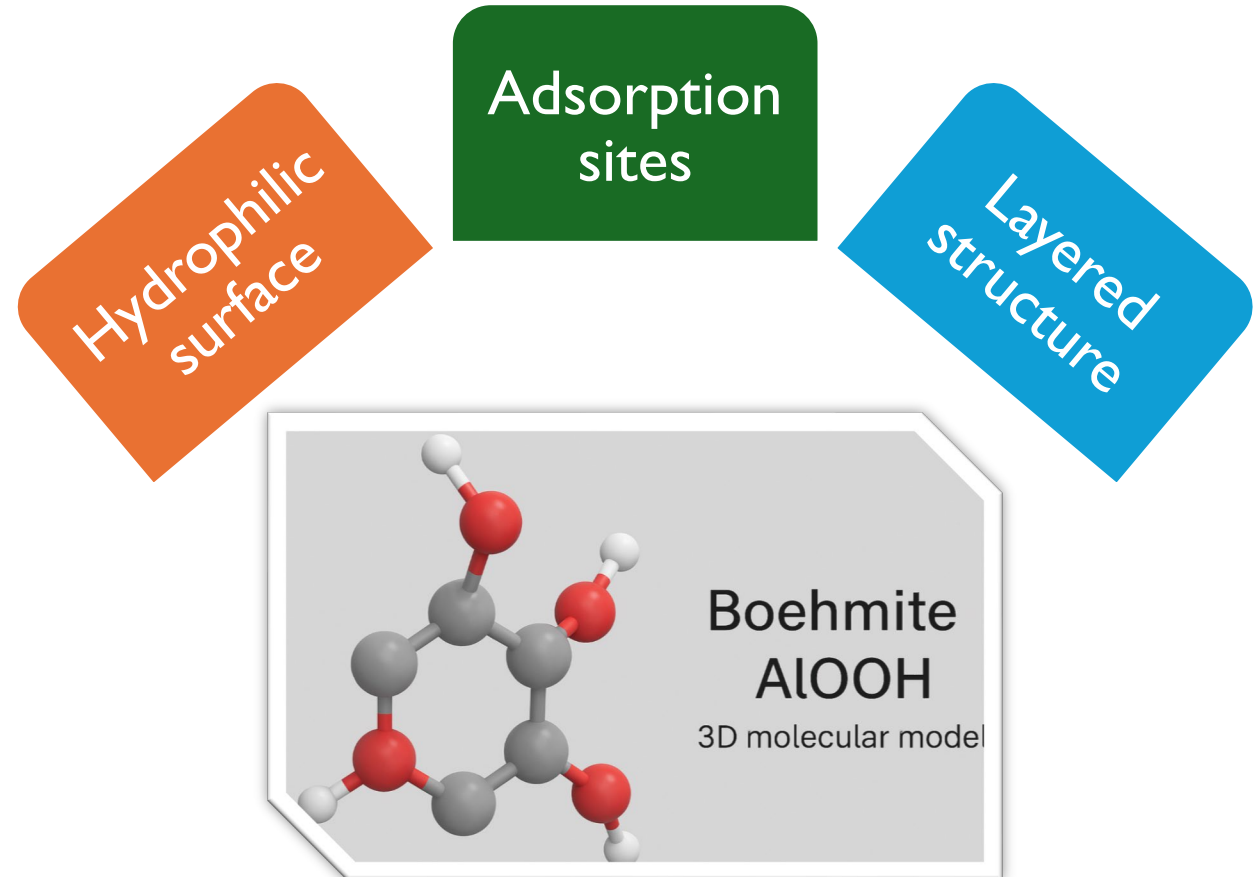
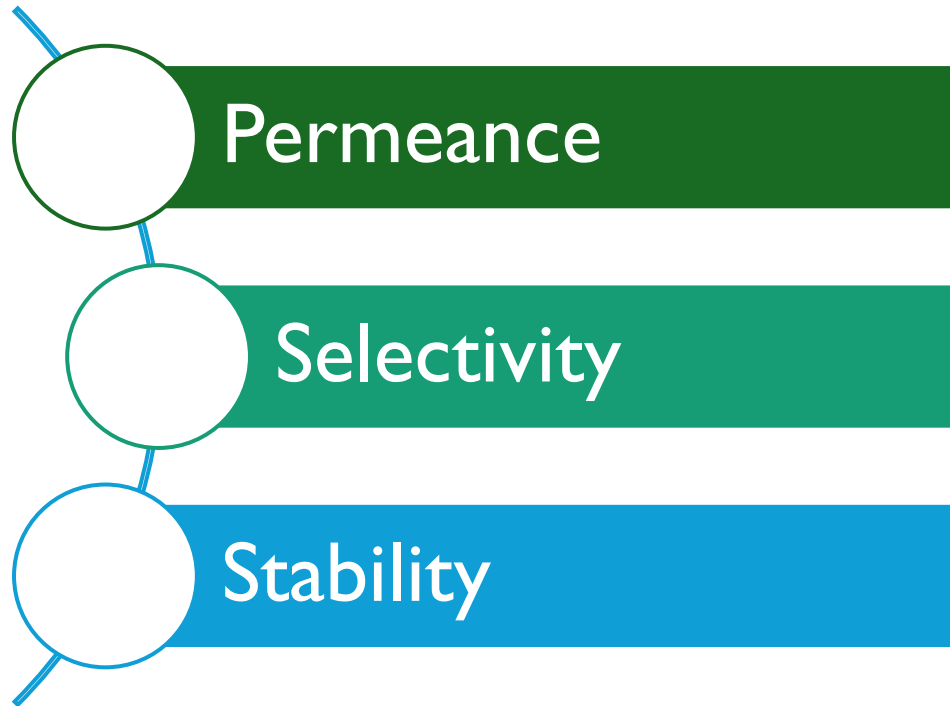
High permeance

Work in conditions where polymeric membranes are not stable



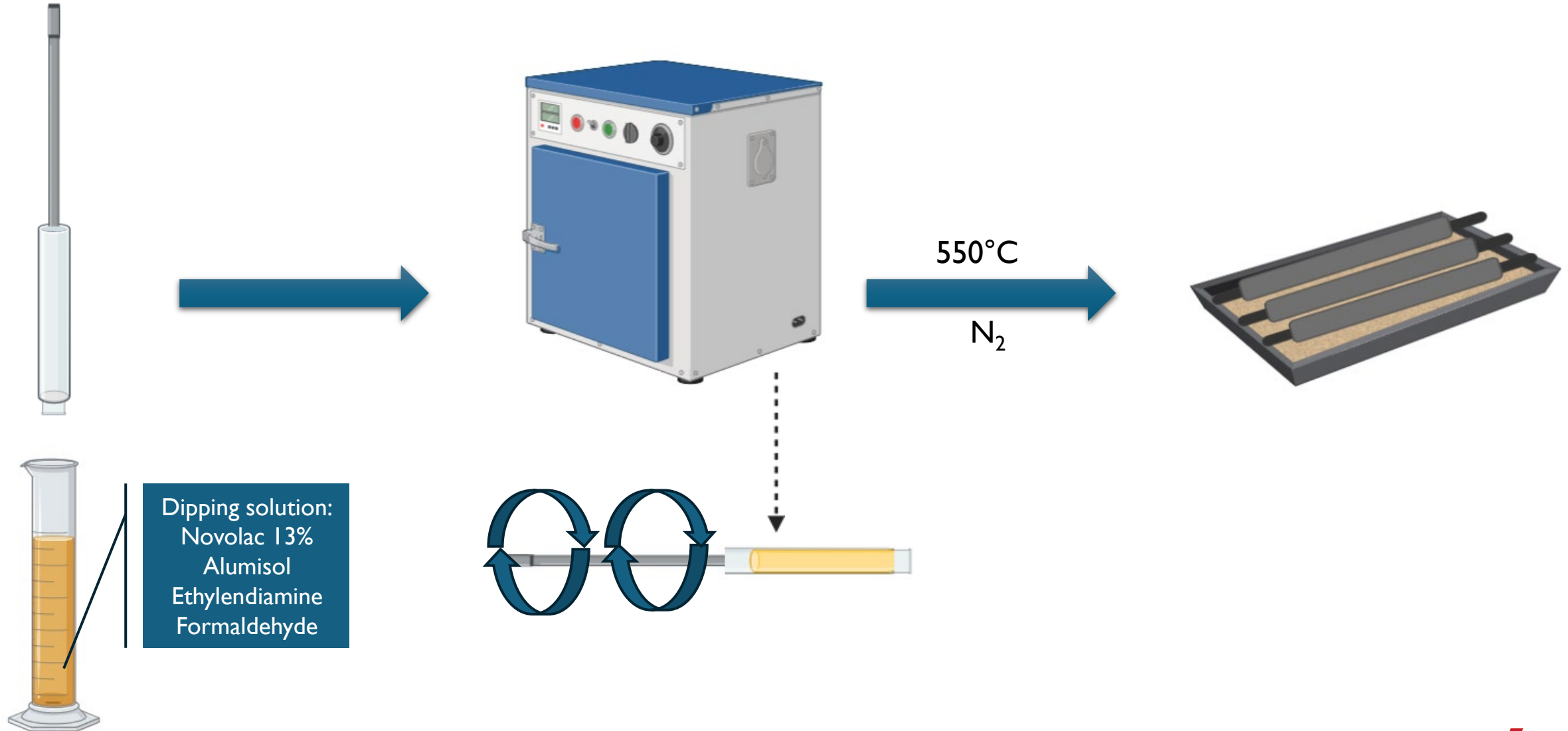


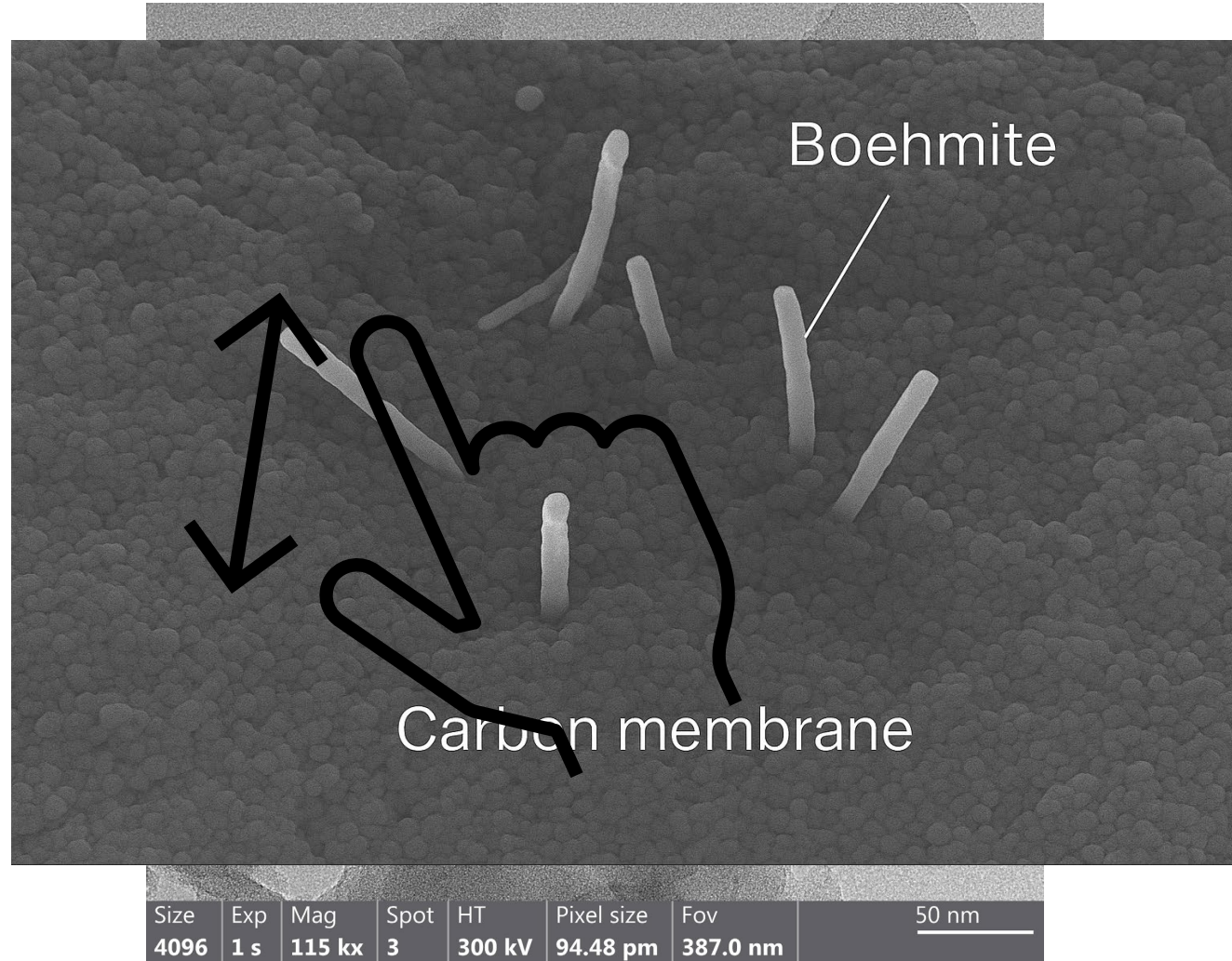
Nanofillers

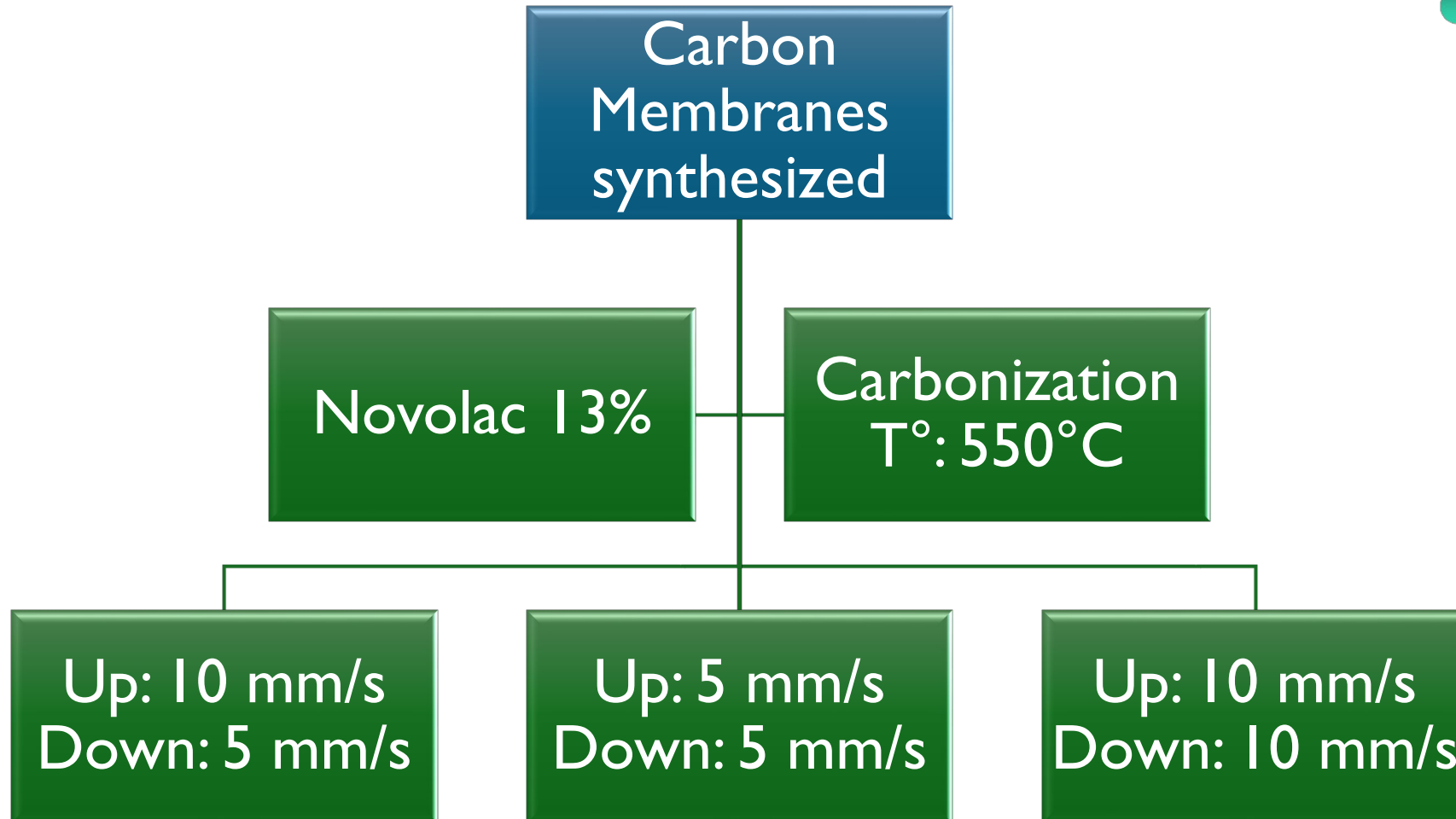




Membrane fabrication





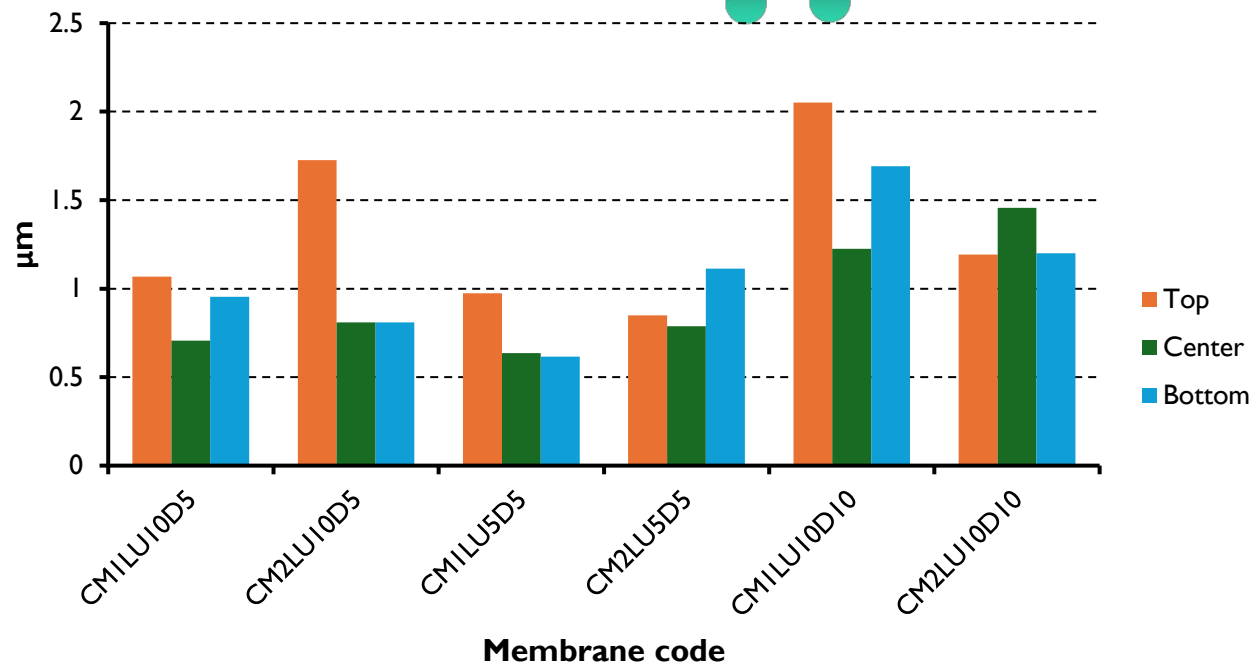
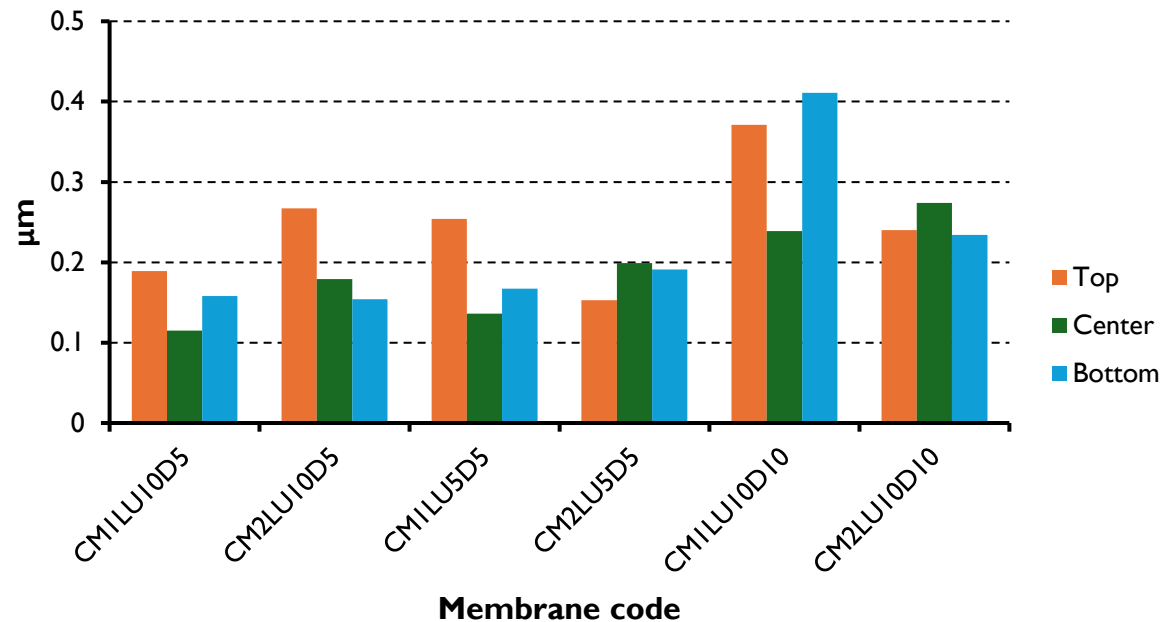




Laser microscope



Ra (Average Roughness)

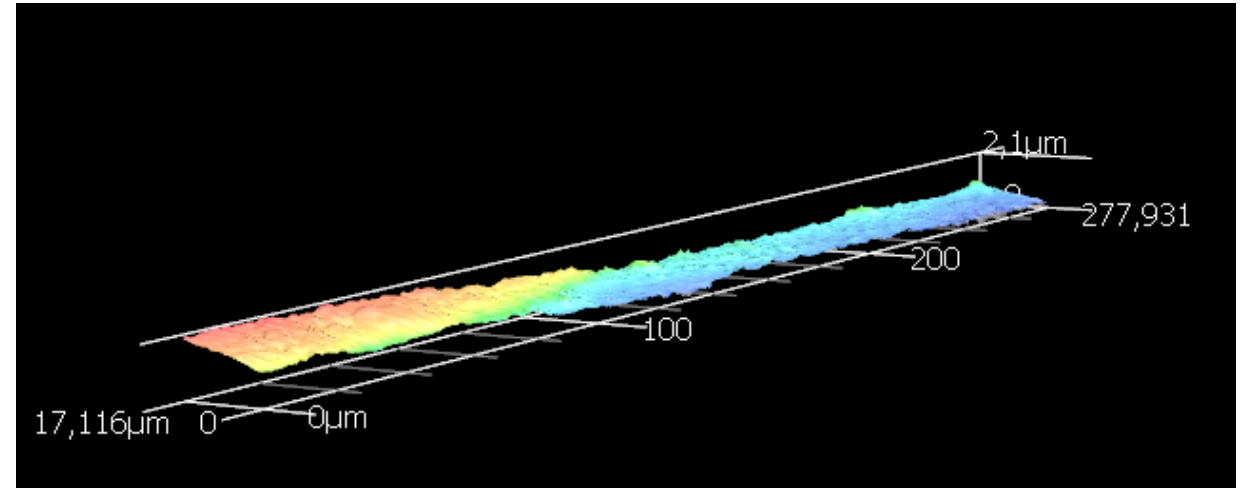
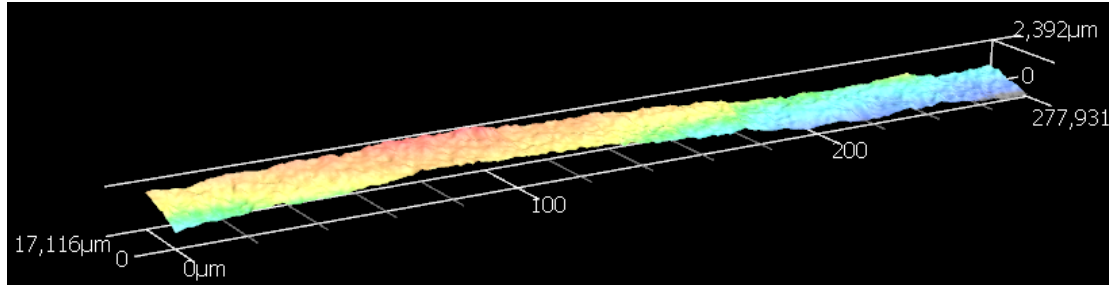


Novolac 13%

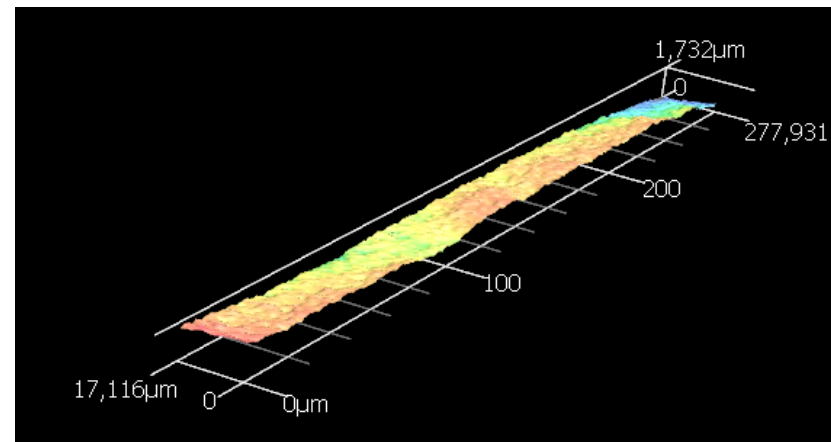
Code	Layer	Dipping speed
CM1LU10D5	1	Up: 10 mm/s-Down: 5 mm/s
CM2LU10D5	2	
CM1LU5D5	1	Up: 5 mm/s- Down: 5 mm/s
CM2LU5D5	2	
CM1LU10D10	1	Up: 10 mm/s- Down: 10 mm/s
CM2LU10D10	2	



Top



Bottom

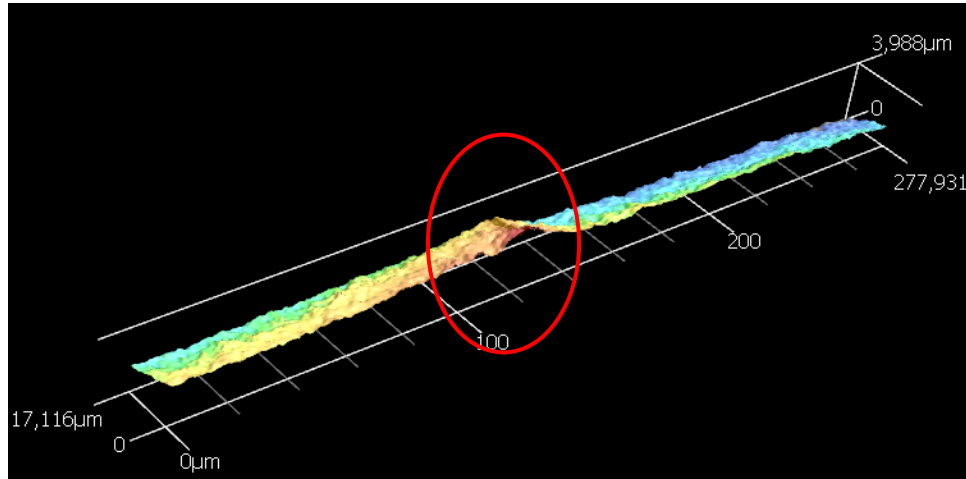




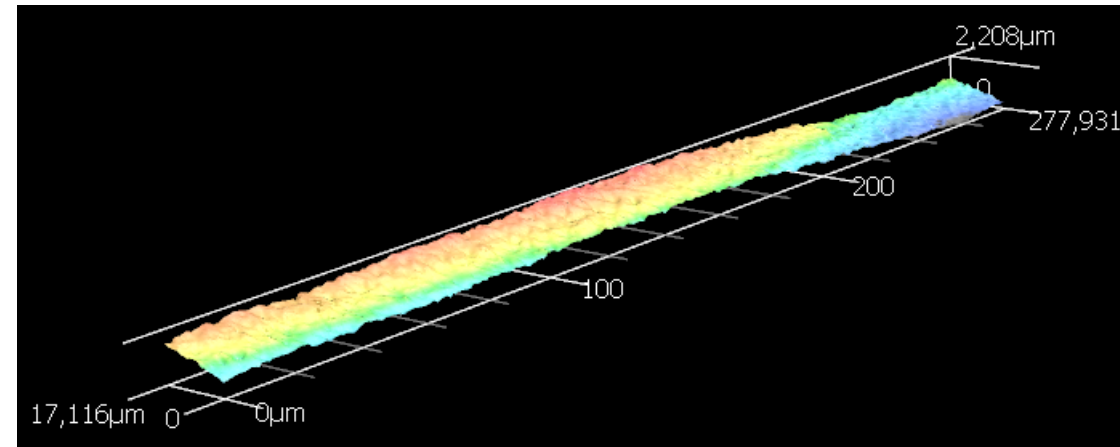
CM2LU10D5



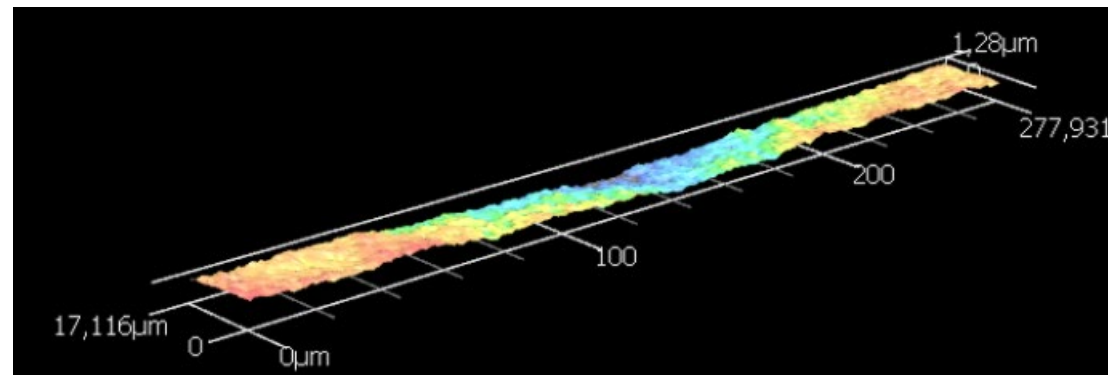
Top



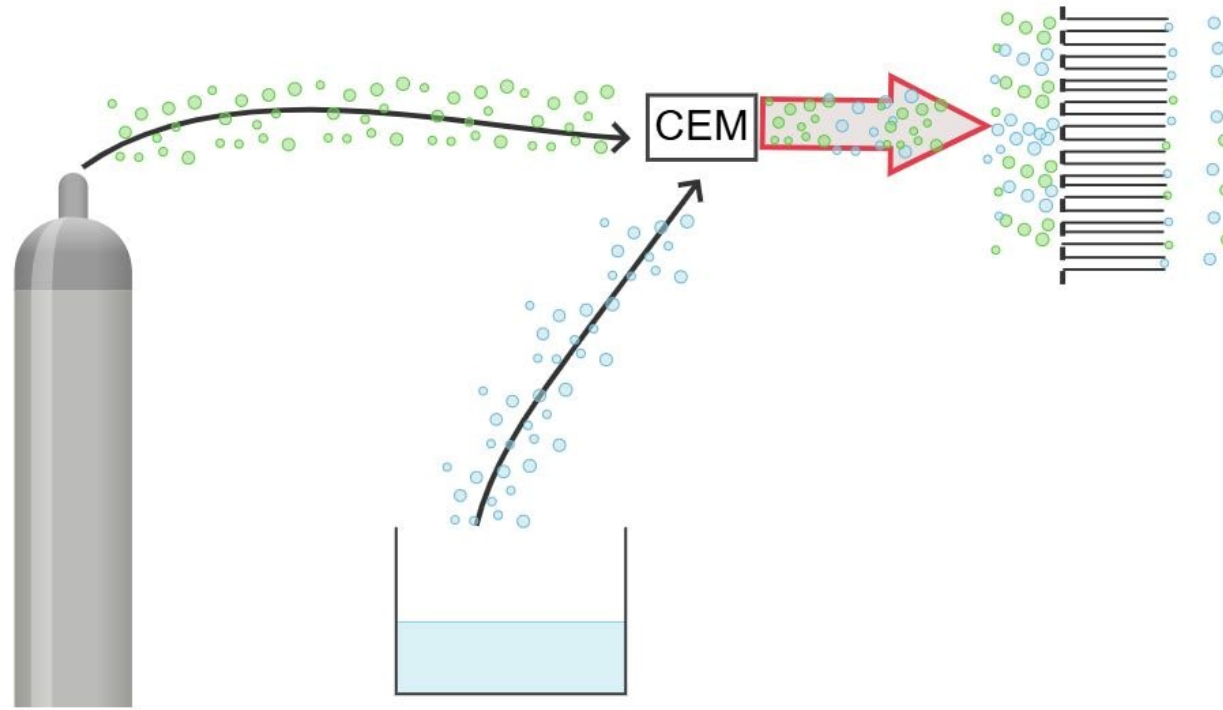
Center



Bottom



Binary gas tests



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

Equation 1

Where:

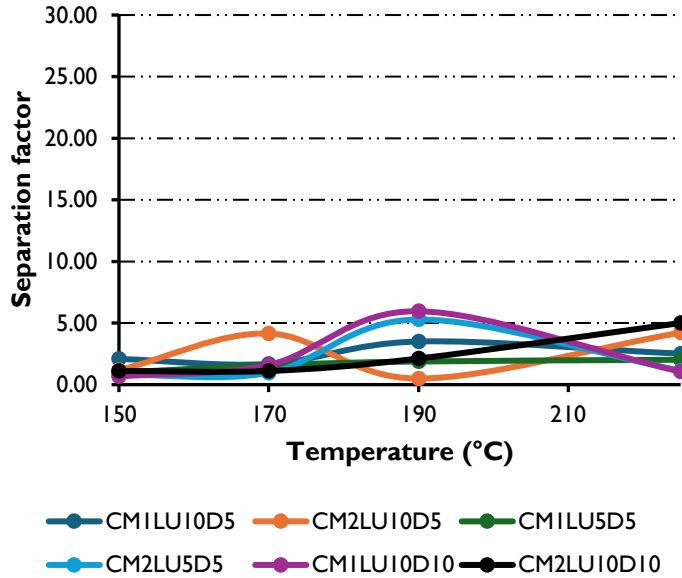
$\alpha_{A/B}$ = separation factor

(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

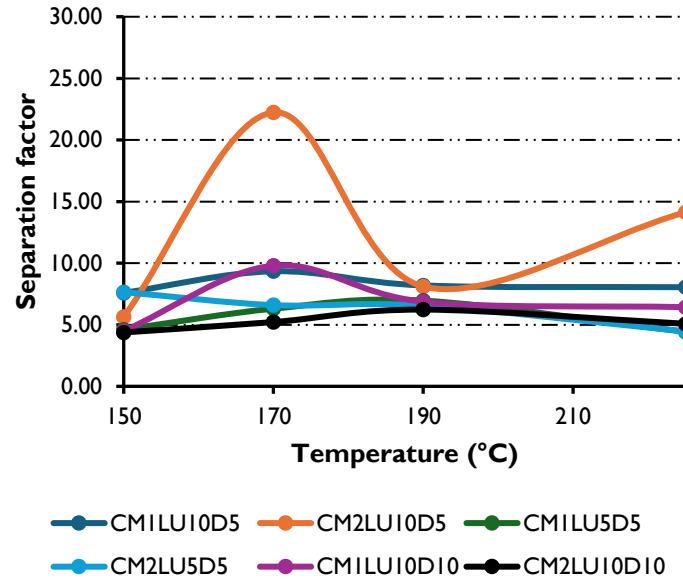


Gas molar fraction (0,25)



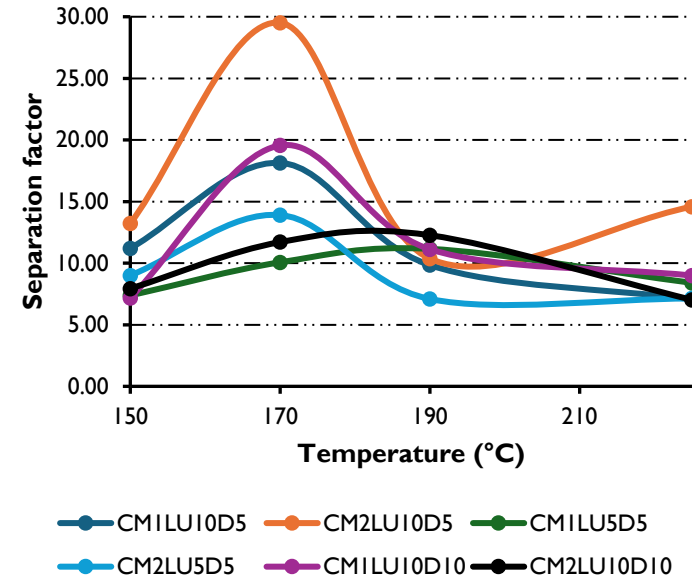
Little affinity for pore walls

Gas molar fraction (0,5)

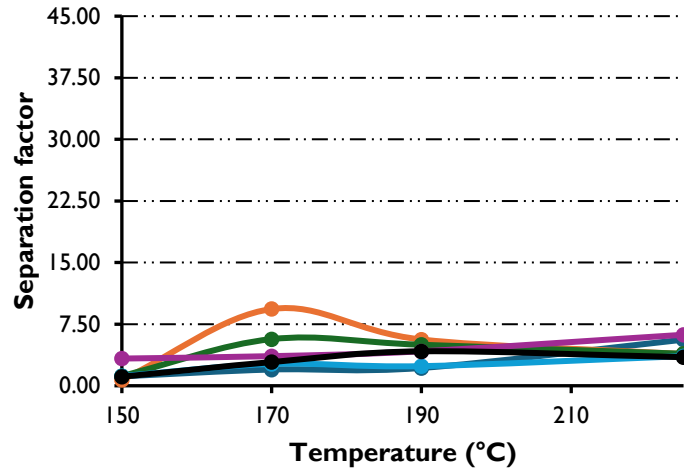


Probably combination of Knudsen diffusion and molecular sieving

Gas molar fraction (0,75)

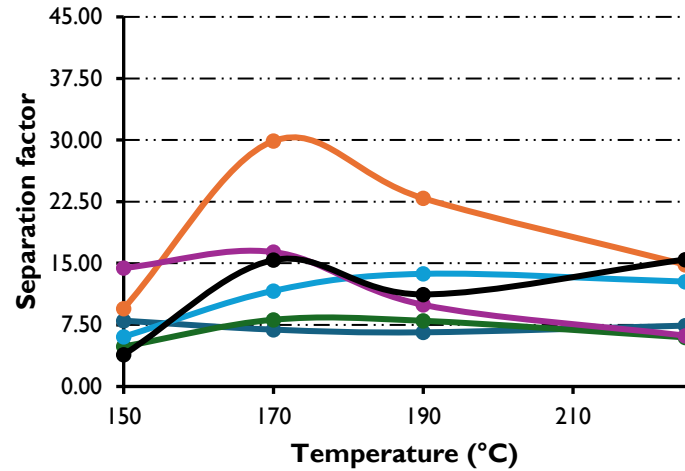


Gas molar fraction (0,25)



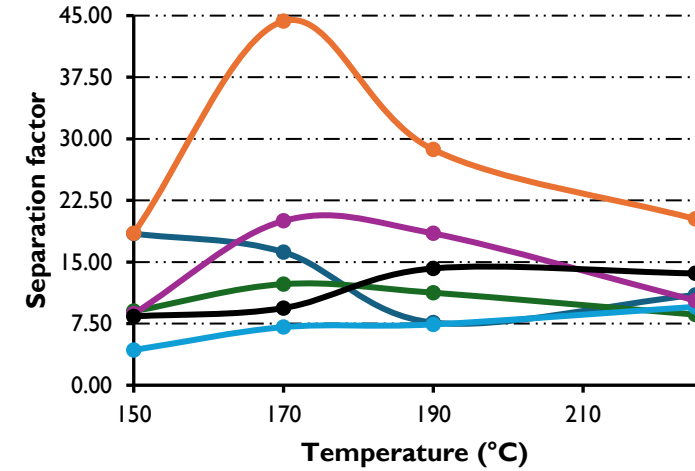
● CM1LU10D5 ● CM2LU10D5 ● CM1LU5D5
● CM2LU5D5 ● CM1LU10D10 ● CM2LU10D10

Gas molar fraction (0,5)



● CM1LU10D5 ● CM2LU10D5 ● CM1LU5D5
● CM2LU5D5 ● CM1LU10D10 ● CM2LU10D10

Gas molar fraction (0,75)



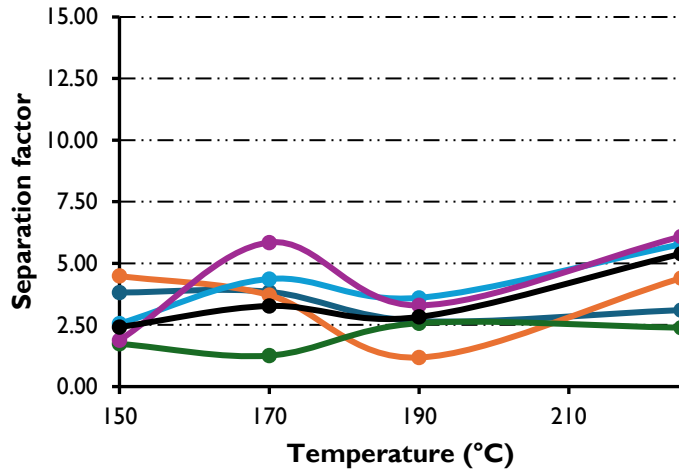
● CM1LU10D5 ● CM2LU10D5 ● CM1LU5D5
● CM2LU5D5 ● CM1LU10D10 ● CM2LU10D10

-OH functionalized CMs improves hydrophilicity and H₂O separation through a dipole-dipole and hydrogen bonding

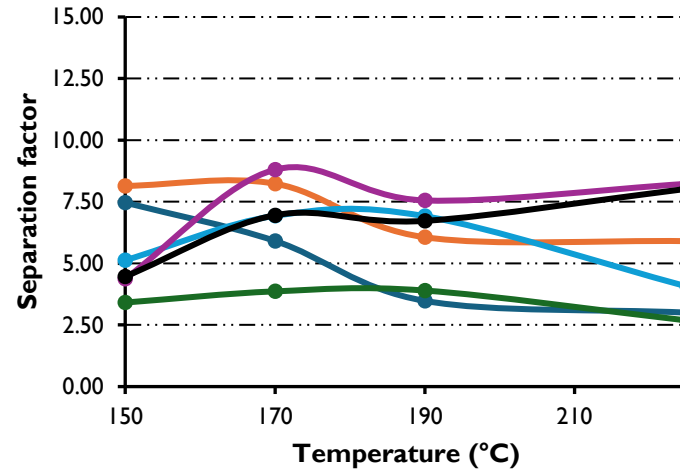
Highly soluble but kinetically trapped on -OH walls



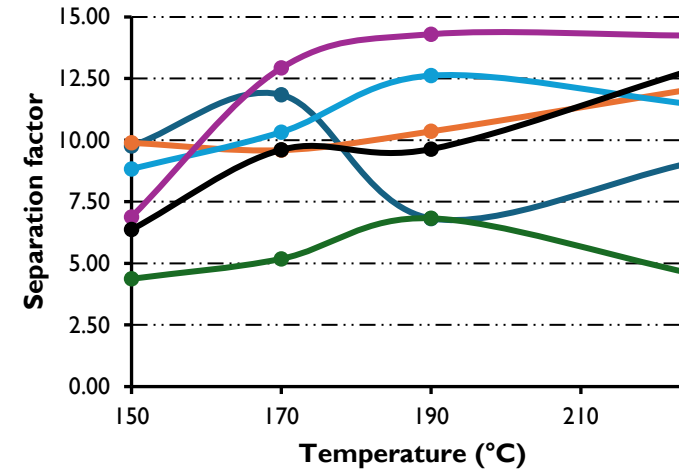
Gas molar fraction (0,25)



Gas molar fraction (0,5)



Gas molar fraction (0,75)



CM1LU10D5 CM2LU10D5 CM1LU5D5
CM2LU5D5 CM1LU10D10 CM2LU10D10

CM1LU10D5 CM2LU10D5 CM1LU5D5
CM2LU5D5 CM1LU10D10 CM2LU10D10

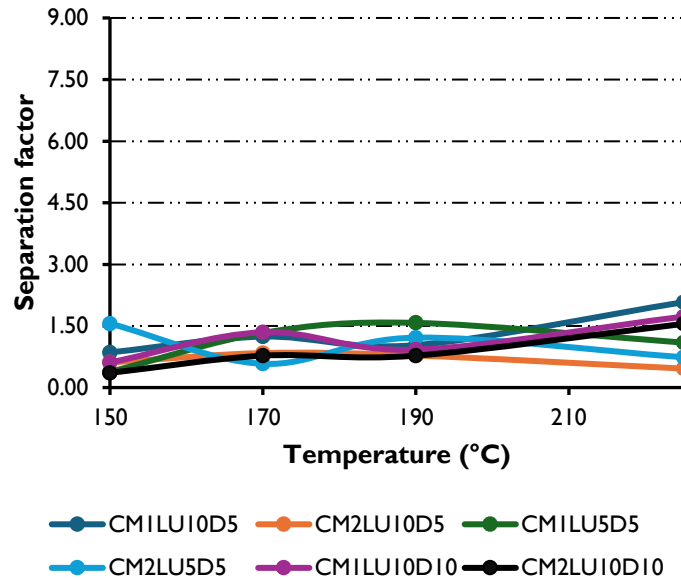
CM1LU10D5 CM2LU10D5 CM1LU5D5
CM2LU5D5 CM1LU10D10 CM2LU10D10

Interacts mainly by quadrupole-dipole forces.

Adsorption moderate but diffusivity higher.

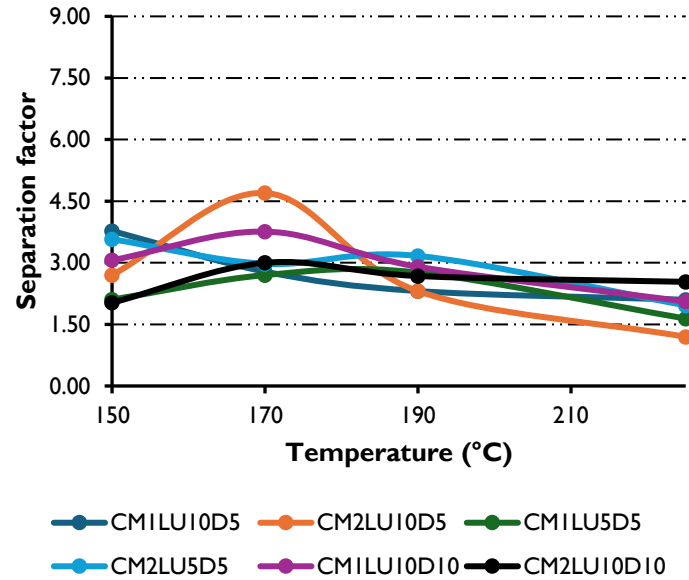


Gas molar fraction (0,25)



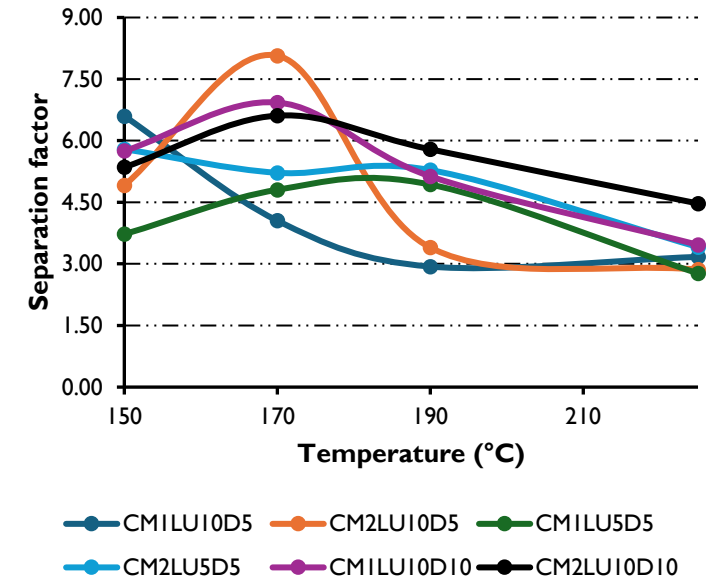
Similar kinetic diameter

Gas molar fraction (0,5)



Better performance at higher temperatures
for a 10 mm/s up dipping speed

Gas molar fraction (0,75)





Conclusions

- Membranes show good performance up to 170°C
- Separation factor depletes for binary gas test at high temperatures (225°C)
- Hydrogen has the lowest separation factor due to its similar kinetic diameter to water.
- Double layer apparently helps to cover some defects but for gases with smaller kinetic diameters, and at high temperatures one layer coating is more stable.



Future steps:

- Single gas test
- Increase Novolac %
- Vary the carbonization temperature
- Permoporosimetry studies
- Thickness measurement