Karlsruher Institut für Technologie

Institut für Technische Chemie

CO_2/N_2-Separation for Utilization by Organo-Silica Hydrotalcite Mixed Matrix Membrane

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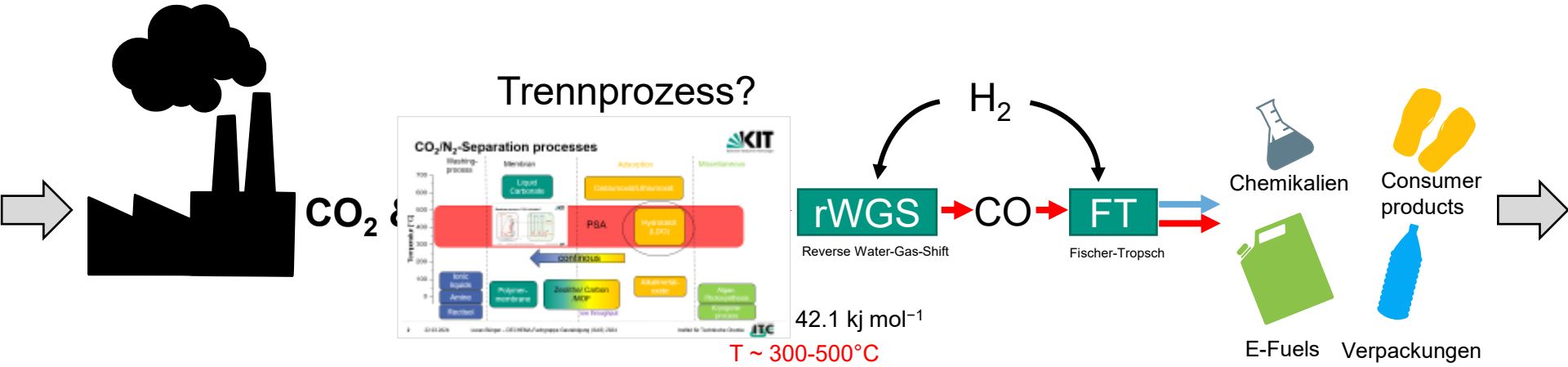
Is Continuous High Temperature High Concentration High throughput N_2/CO_2-separation possible?



CO_2/N_2-Separation processes

Washing-process

Membran

Adsorption

Miscellaneous

Temperatur [°C]

700
600
500
400
300
200
100
0

Liquid Carbonate

Calciumoxid/Lithiumoxid

PSA

Hydrotalcit (LDO)

continous

Ionic liquids

Amine

Rectisol

Polymer-membrane

Zeolithe/ Carbon /MOF

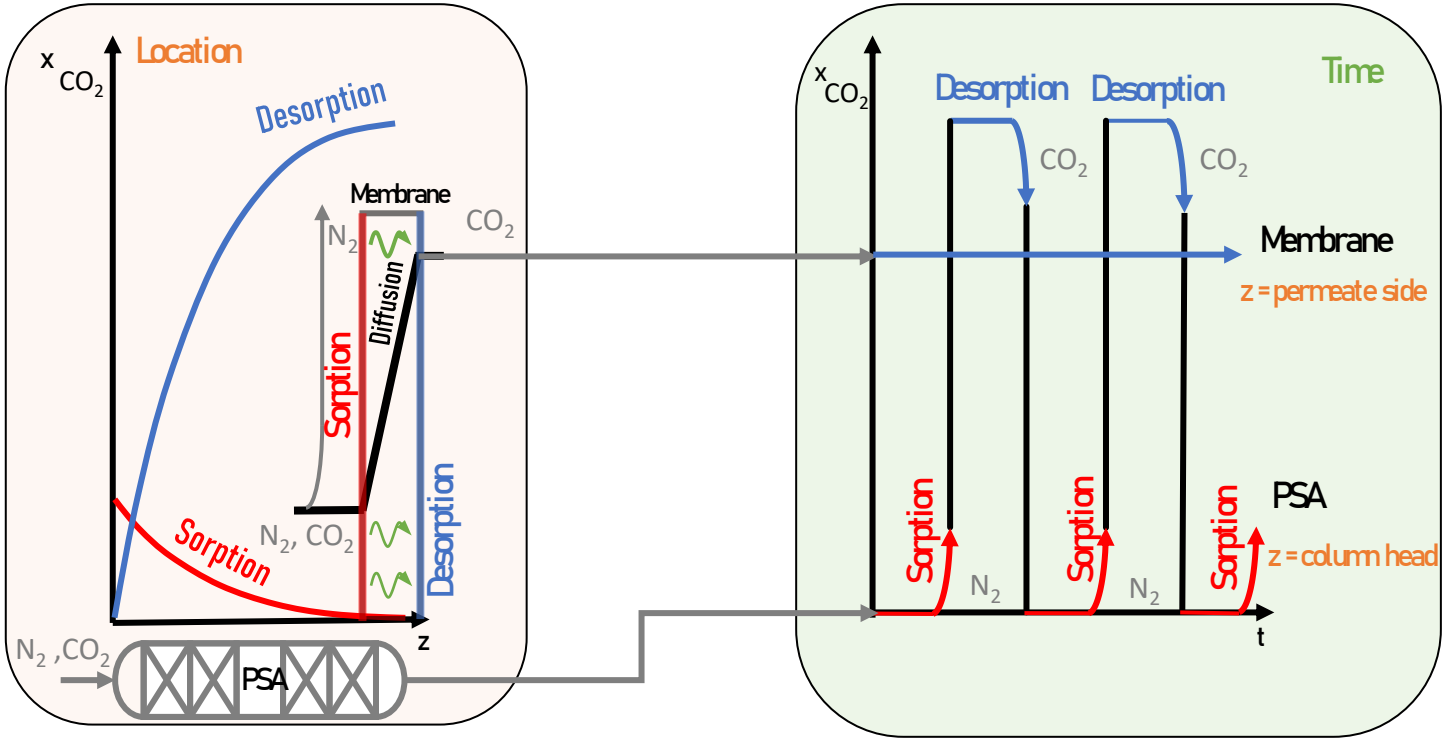
low throughput

Alkalimetal-oxide

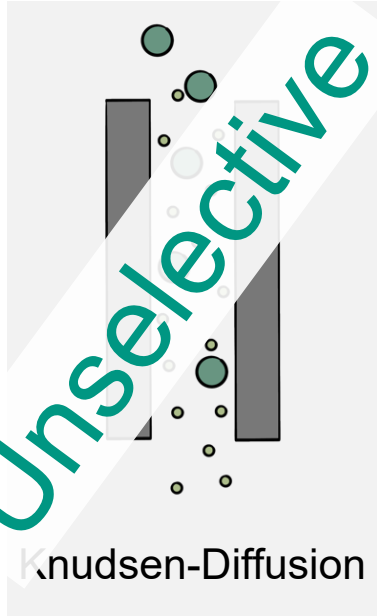
Algae, Photosynthesis

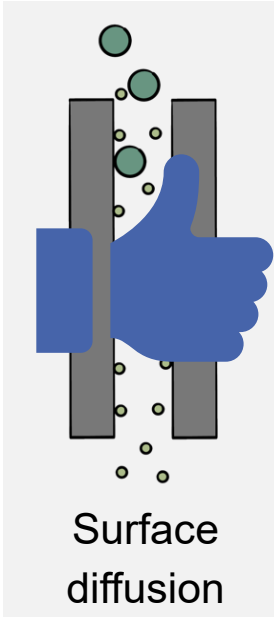
Kryogene-process

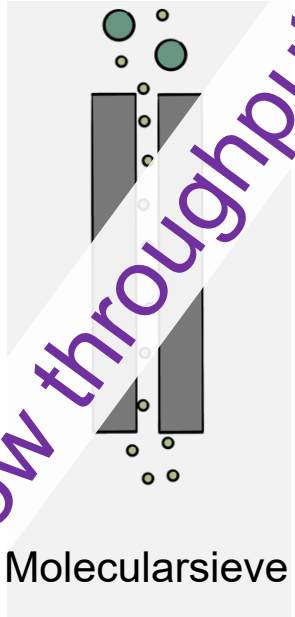
Membrane process = PSA, but better?



(Gas)Transport in porous Membranes







$\lambda < d_p$

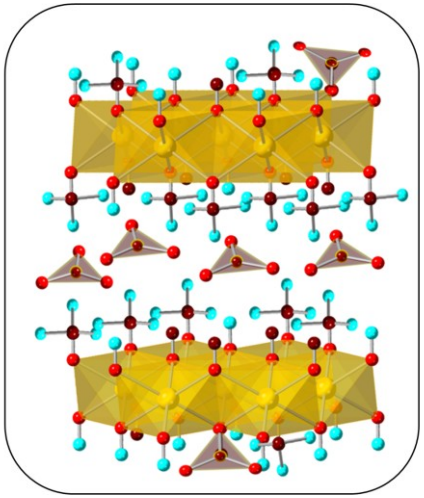
$\lambda > d_p$

Adsorption, Diffusion

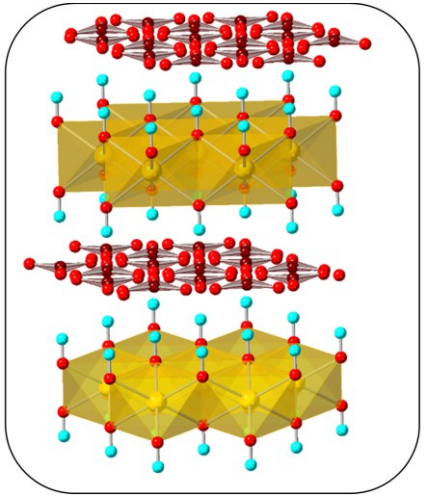
$d_{M1} < d_p$
$d_{M2} > d_p$

Hydrotalcite like compound (HTlc) Membrane

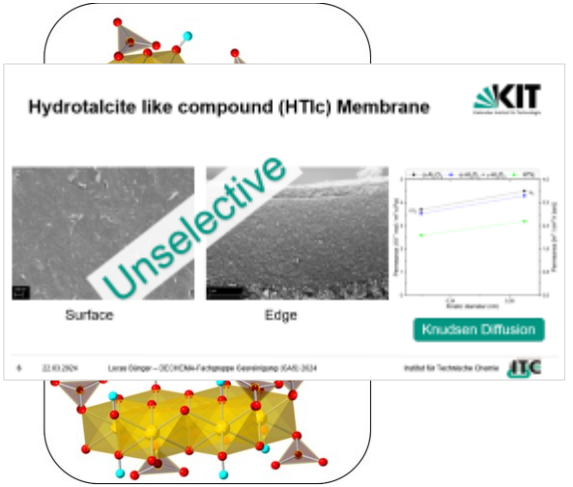
Layered HTlc → Delaminated HTlc → HTlc Nanosheet



Delamination

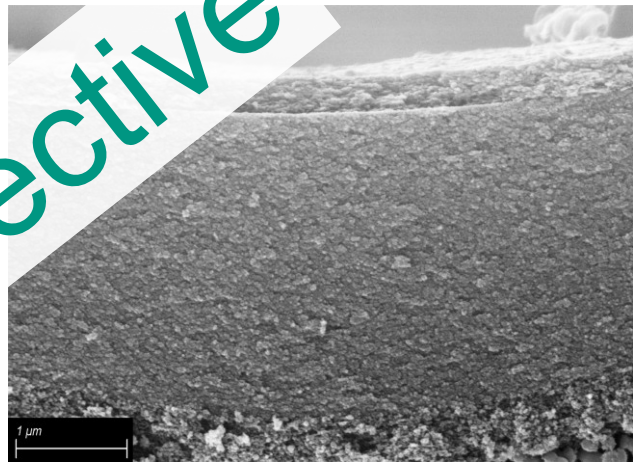


Calzination



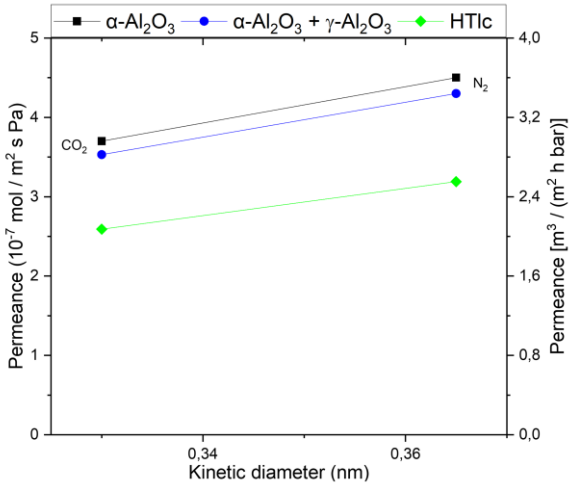
Hydrotalcite like compound (HTlc) Membrane

Surface



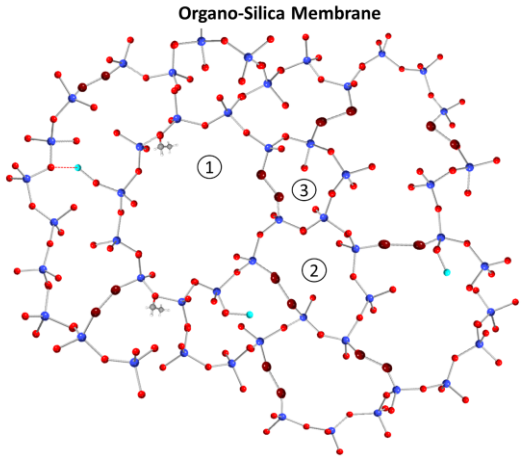
Edge

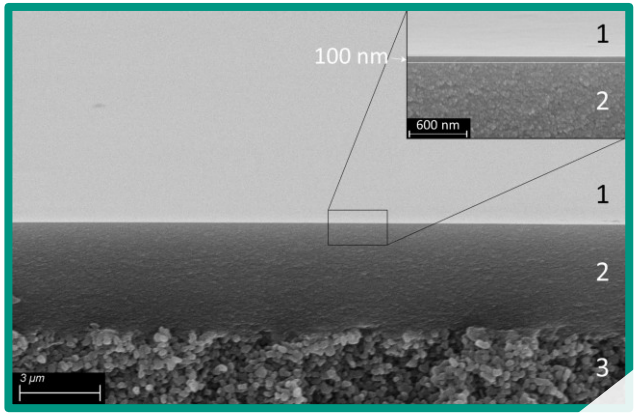
Unselective



Knudsen Diffusion

Adjustig Microstructure – but how?



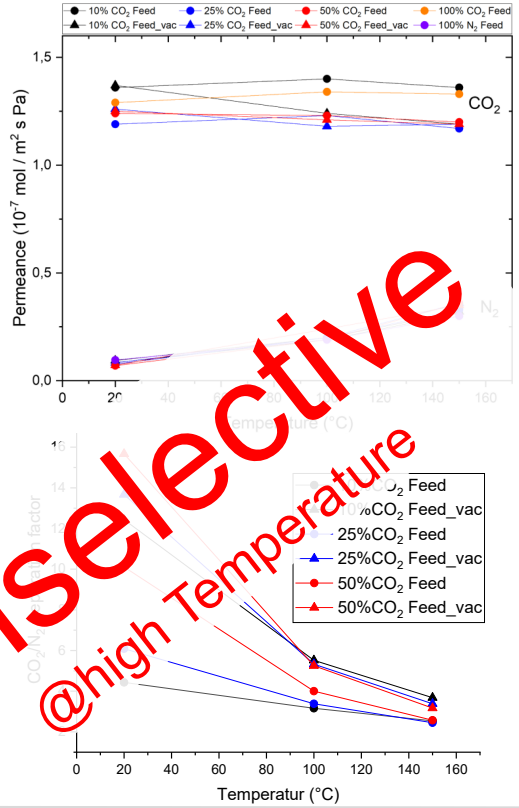


① Mesopore > 2nm

② 1nm < Micropore < 2nm

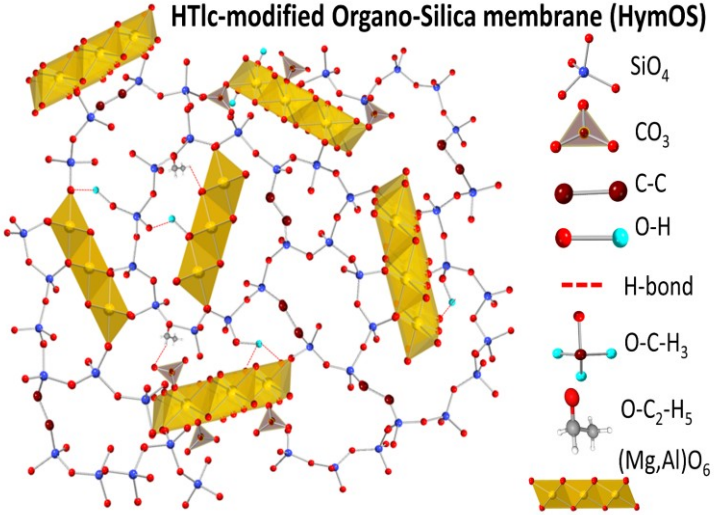
③ Ultramicropore < 1nm

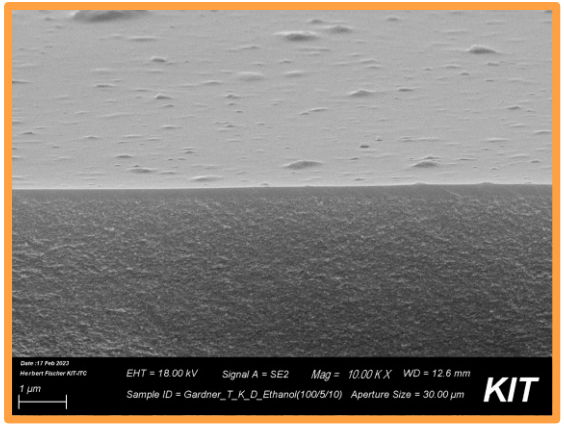
Organo-Silica Membrane

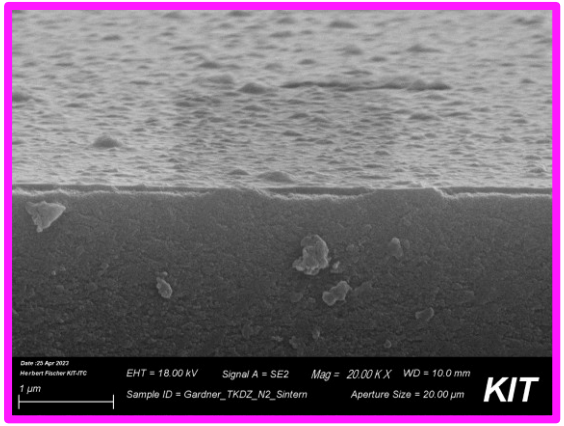


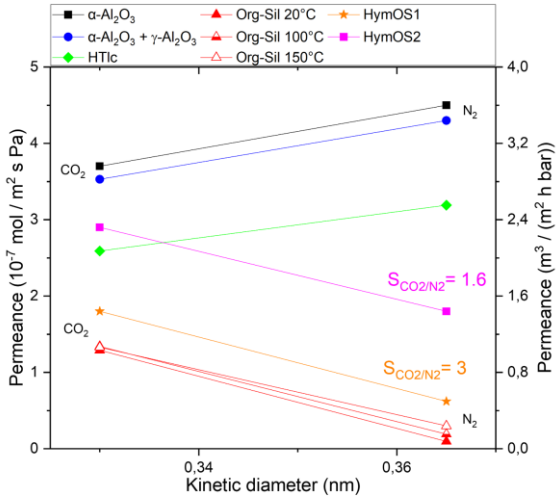
Unselective @high Temperature

Combination

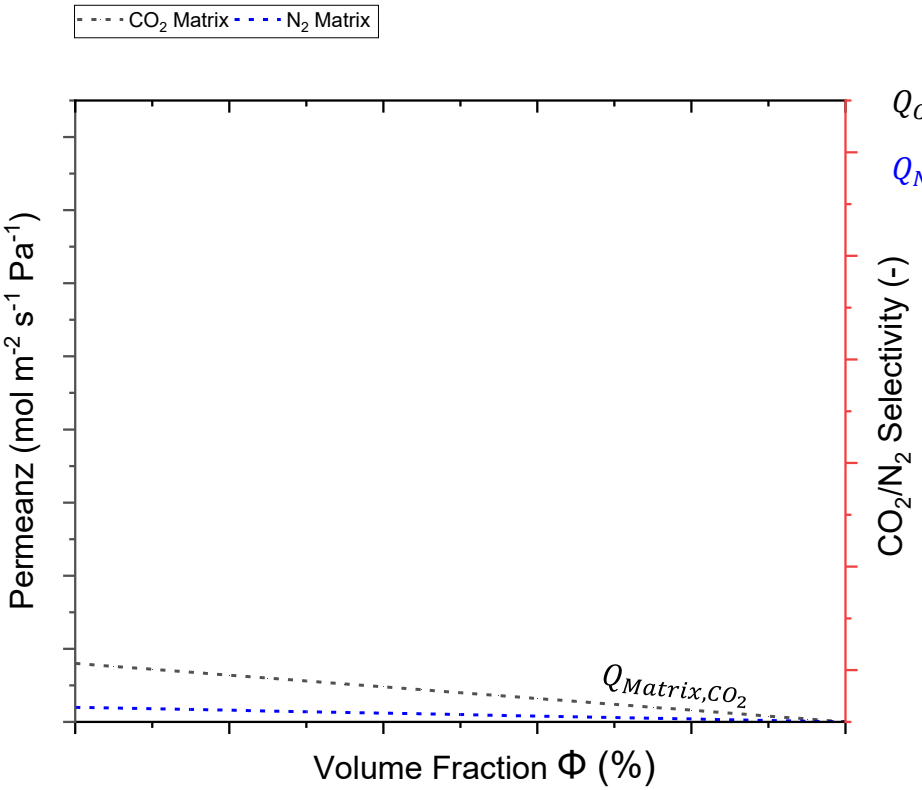








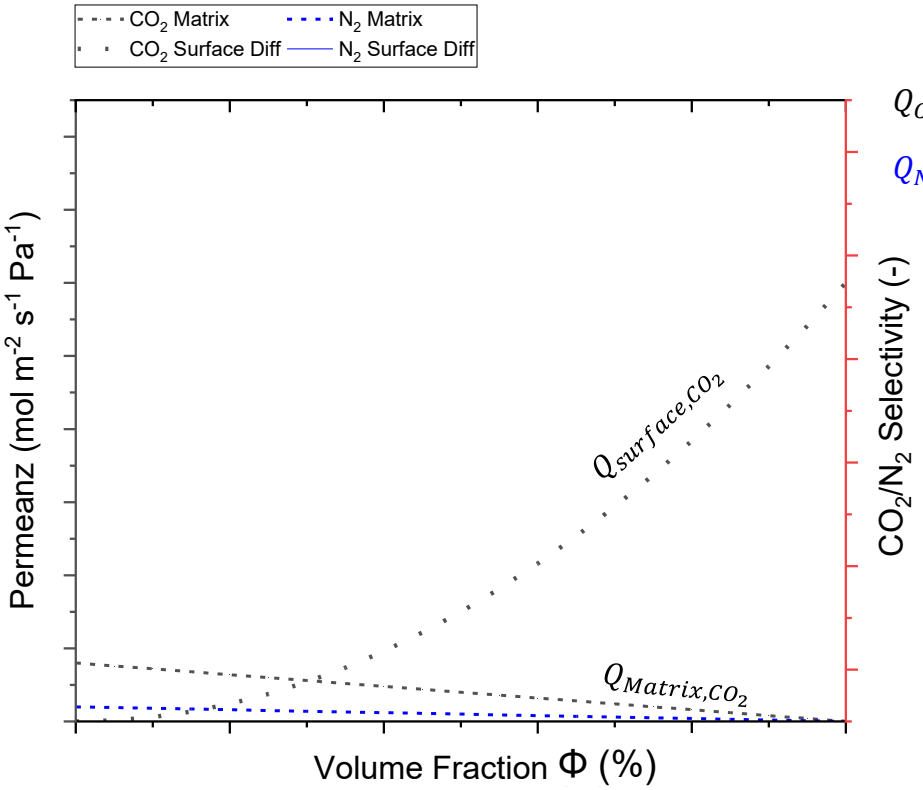
What happened?



$$Q_{CO_2,MMM} = (1 - \phi_{HTlc})Q_{CO_2,Silica}$$

$$Q_{N_2,MMM} = (1 - \phi_{HTlc})Q_{N_2,Silica}$$

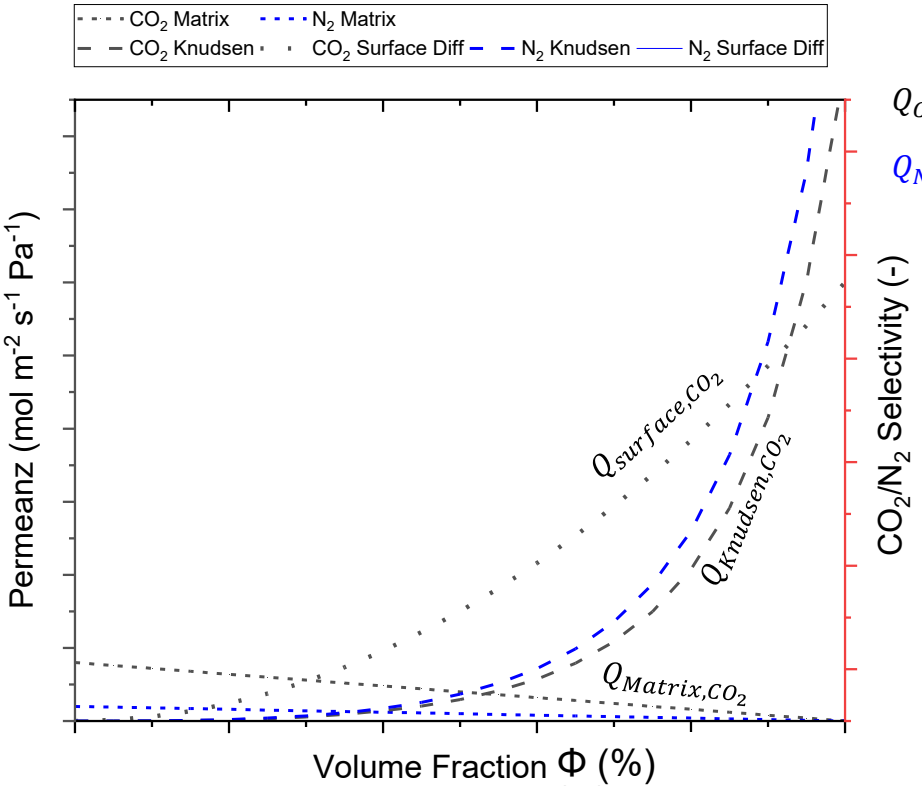
What happened?



$$Q_{CO_2,MMM} = (1 - \phi_{HTlc})Q_{CO_2,Silica} + \phi_{HTlc}\,(Q_{CO_2,HTlc.S}$$

$$Q_{N_2,MMM} = (1 - \phi_{HTlc})Q_{N_2,Silica} + \phi_{HTlc}\,(Q_{N_2,HTlc}$$

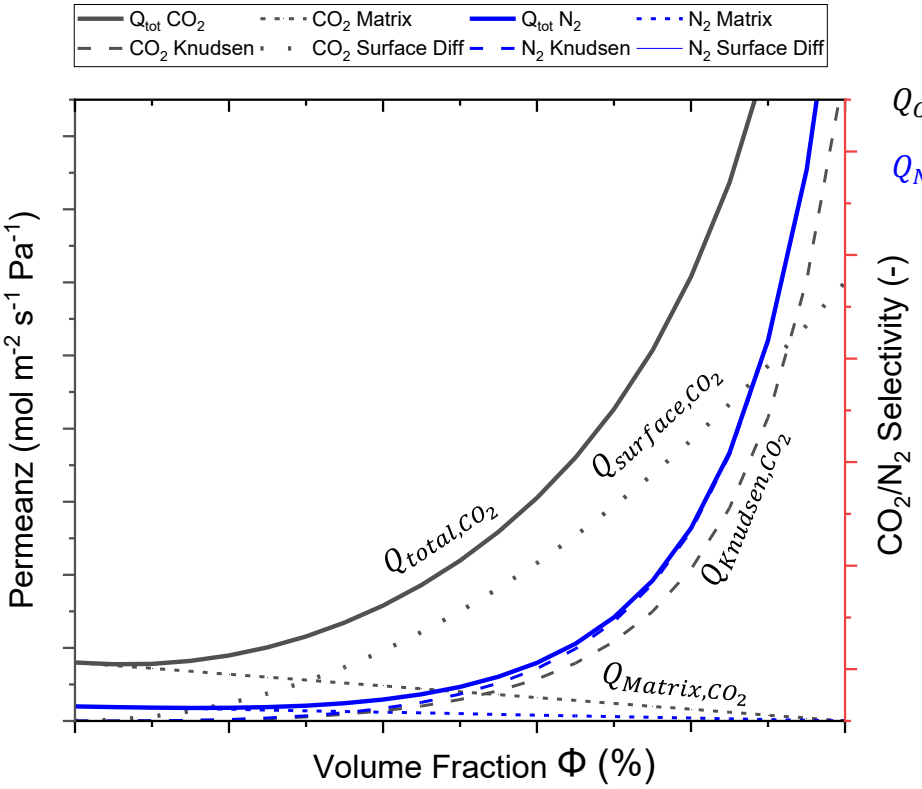
What happened?



$$Q_{CO_2,MMM} = (1 - \phi_{HTlc})Q_{CO_2,Silica} + \phi_{HTlc}\,(Q_{CO_2,HTlc.S} + Q_{CO_2,HTlc,Kn})$$

$$Q_{N_2,MMM} = (1 - \phi_{HTlc})Q_{N_2,Silica} + \phi_{HTlc}\,(Q_{N_2,HTlc} + Q_{N_2,HTlc,Kn})$$

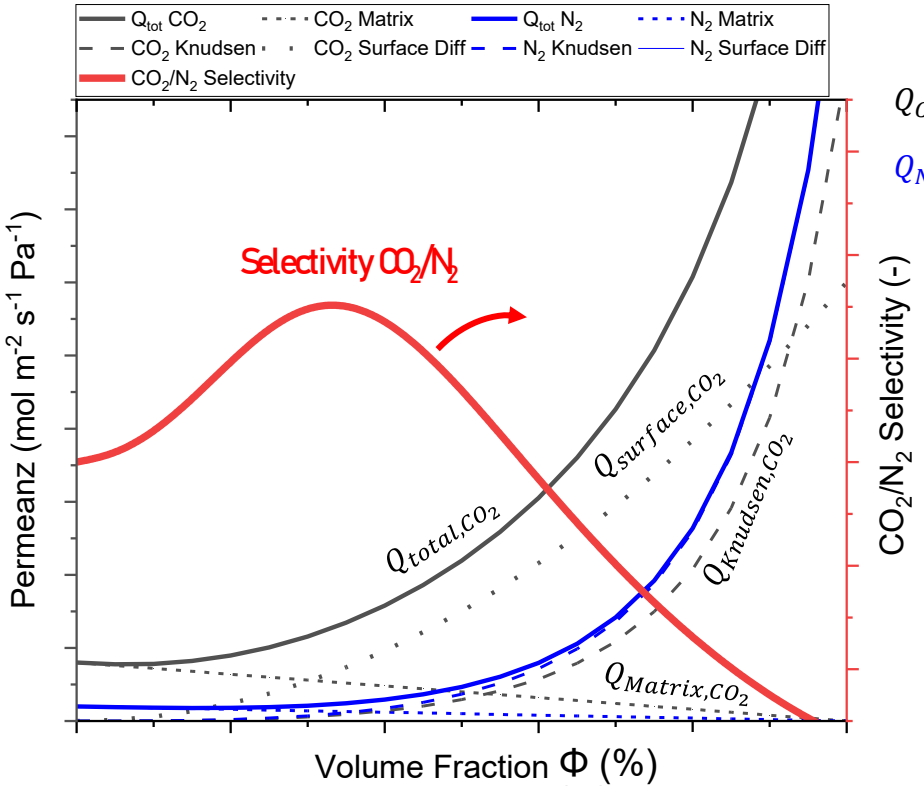
What happened?



$$Q_{CO_2,MMM} = (1 - \phi_{HTlc})Q_{CO_2,Silica} + \phi_{HTlc}\,(Q_{CO_2,HTlc.S} + Q_{CO_2,HTlc,Kn})$$

$$Q_{N_2,MMM} = (1 - \phi_{HTlc})Q_{N_2,Silica} + \phi_{HTlc}\,(Q_{N_2,HTlc} + Q_{N_2,HTlc,Kn})$$

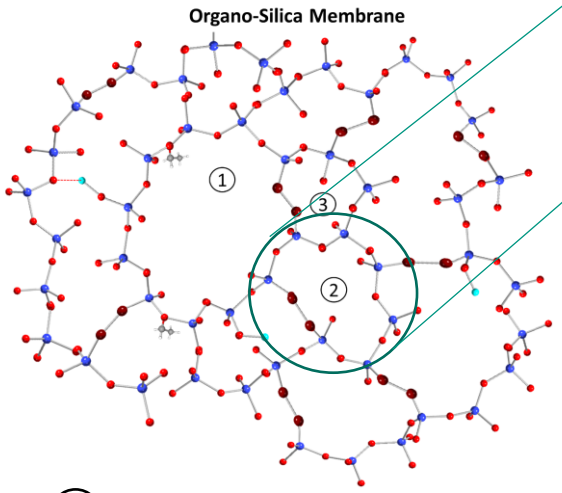
What happened?



$$Q_{CO_2,MMM} = (1 - \phi_{HTlc})Q_{CO_2,Silica} + \phi_{HTlc}\,(Q_{CO_2,HTlc.S} + Q_{CO_2,HTlc,Kn})$$

$$Q_{N_2,MMM} = (1 - \phi_{HTlc})Q_{N_2,Silica} + \phi_{HTlc}\,(Q_{N_2,HTlc} + Q_{N_2,HTlc,Kn})$$

Conclusion – pore size! And number



Micropores
Highly affinitive surface

① Mesopore > 2nm

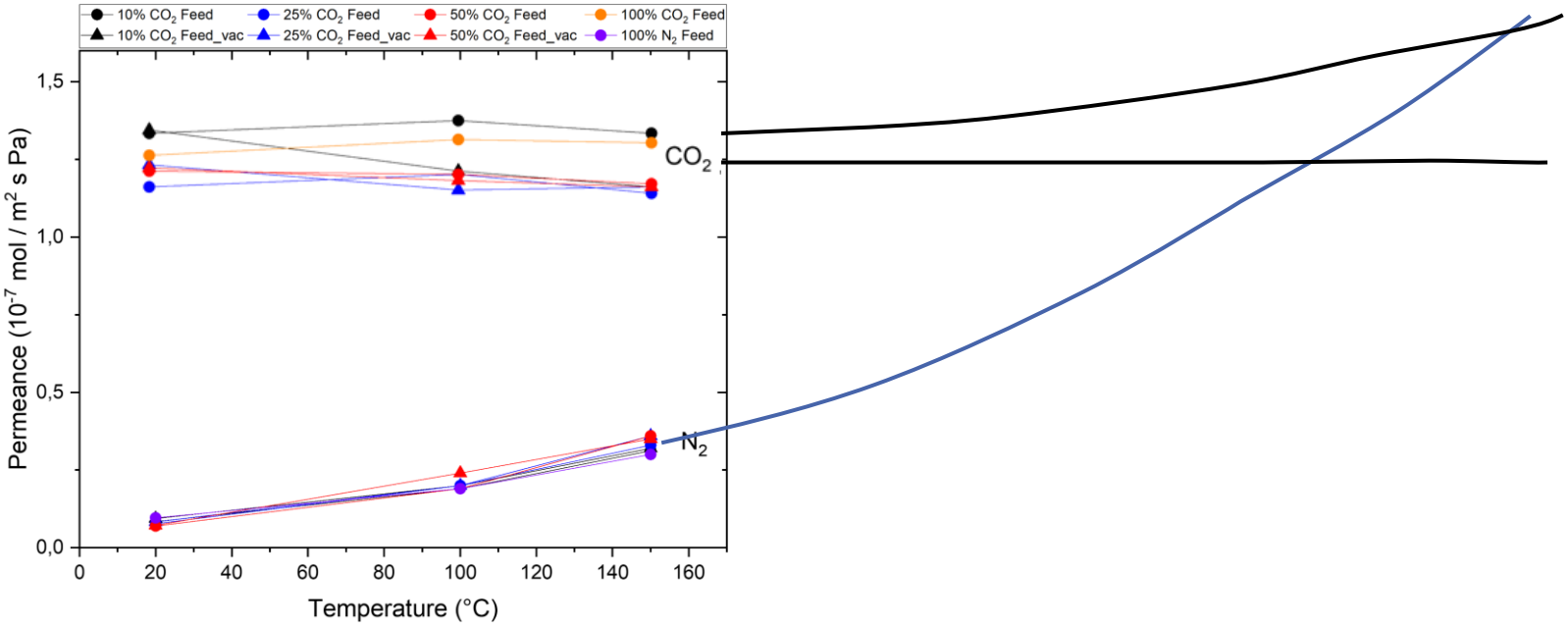
② 0,7nm < Micropore < 2nm

③ Ultramicropore < 0,7nm

Influence on pore size and number:

- Water/Silica & Silica/Acid
- Reaction time & temperature
- Stirring
- Sol aging (dilution, particle grow)
- Drying conditions (humidity, duration, temperature, defects)
- Sintering (atmosphere, temperature, time, defects)
- Coating technique (dilution, coating times, airborne particles)
- Membrane aging (measurement immediately after fabrication or after storage period)
- …

Conclusion – mass transfer mechanism!



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