Supported IL Membrane: Stability and Absorption and Permeation Selectivities

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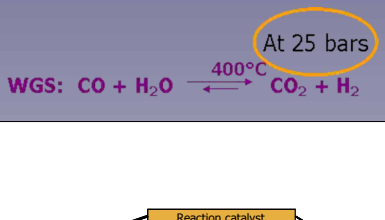
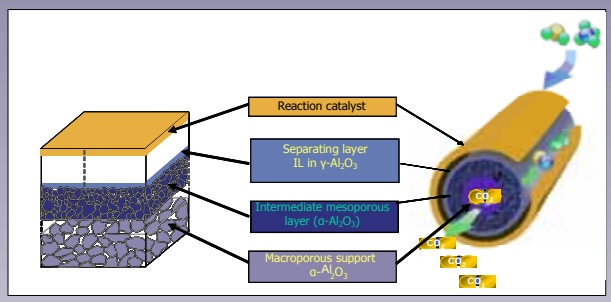
Goal

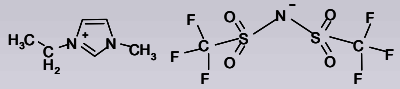
Steam reforming and the water gas shift are the key reactions for the production of hydrogen from fossil fuels. By removing carbon dioxide from the reaction mixture as it is produced, the equilibrium can be shifted to the product side. The goal is to develop a membrane reactor based on CO_2-selective Supported Ionic liquid Membrane (SILM) for the water gas shift reaction. The selected SILM should have both high solubility and high diffusivity.





Schematic diagram of separation-enhanced membrane reactor

Selected Ionic liquid for supported ionic liquid membrane

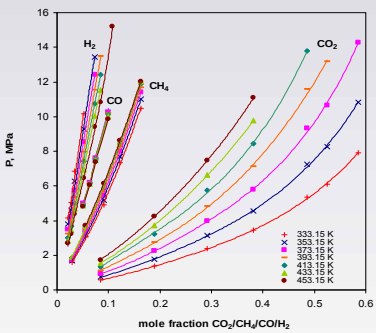


1-ethyl-3-methyl-imidazolium-bis-(trifluoromethylsulphonyl) imide

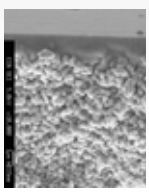
abbreviation: [emim][Tf_2N]

Results

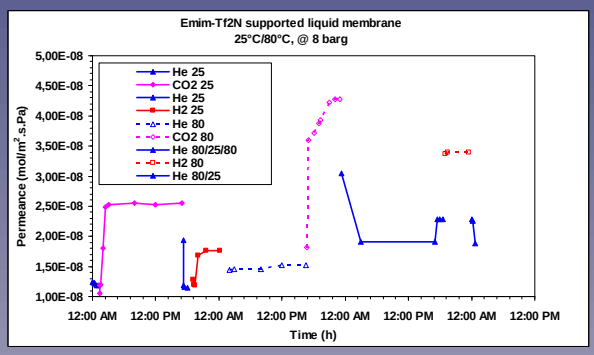
comparison of CO_2, CO, H_2, and CH_4 solubilities in [bmim][Tf2N]



Pressure-concentration → absorption selectivity CO_2/H_2 between 5 and 15 depending on chosen p, T similar to the emim analogue.



Membrane preparation:
IL confined to γ-Al_2O_3 layer



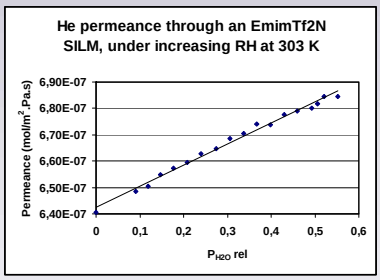
Single gas permeances of He, H_2 and CO_2 at 25 and 80°C

What do we learn from this picture?
- Equilibration is extremely slow
- Permeability of other gases increases after CO_2 has been permeated
- Permeability increases with T
- Permselectivity decreases with T

Table: Average plateau values of the single gas permeances at stable temperature

Condition (°C)	He 25	CO_2 25	He 25	H_2 25	He 80	CO_2 80	He 80/25/80	H_2 80	He 80/25
Average plateau permeancy (10^{-8} mol/m²sPa)	1,2	2,5	1,1	1,7	1,4	4,2	1,9	3,3	1,8

Highest permselectivity measured @ 25°C: 2,3



Stability with water vapour: increasing partial water vapour pressure leads to increasing He flux: SILM degrades

Conclusions

- Different T absorption fingerprint for CO_2 and CH_4 as compared to CO and H_2
- Absorption selectivity too low: <15
- Permselectivity even lower: <2,3
- Kinetics too slow
- Decreasing permselectivity with increasing T
- Not stable against water vapour (abundantly present in WGS) degradation likely but not fully proven

So: first investigate and try to understand the changes in liquid structure with different sorbates and then back to drawing table to design a better IL to have higher CO_2 solubility by possible methods such as increasing fluorination of the IL, or using nonfluorinated ILs containing ether linkages and flexible alkyl chains to increase free volume.

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