

THE SEPARATION OF CARBON DIOXIDE FROM CO₂/N₂/O₂ MIXTURES USING COMMERCIAL MEMBRANE MODULES

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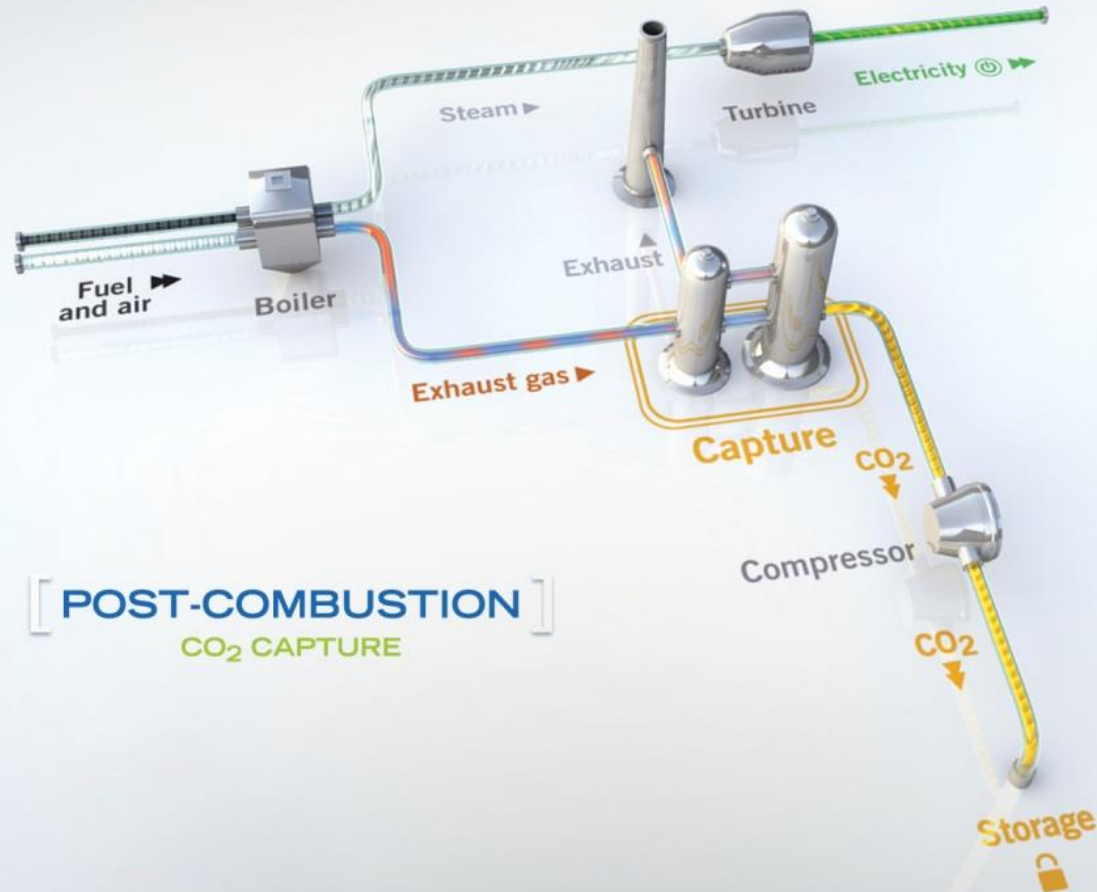
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US DOE REPORT

Any system realizing the separation of CO₂ from flue gases generated during the combustion of fossil fuels has, first, to produce an enriched stream with CO₂ concentrations exceeding 95 vol.% and, second, to ensure CO₂ recovery above 90%





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Innovative technologies for post-combustion capture

- hybrid (adsorption + membranes)
- poly(ionic liquid) membranes
- enzyme-enhanced absorption





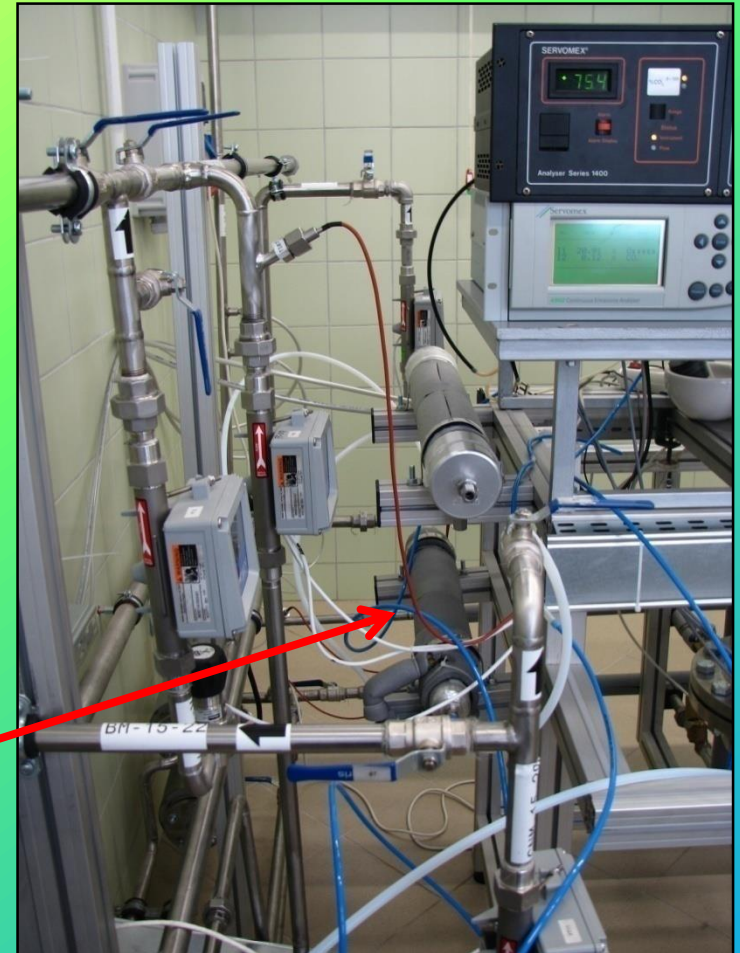
adsorption unit

$$F_Z = 7.5 \text{ m}_n^3/\text{h}$$

$$x_{ZCO_2} = 12.6 \text{ vol. \%}$$

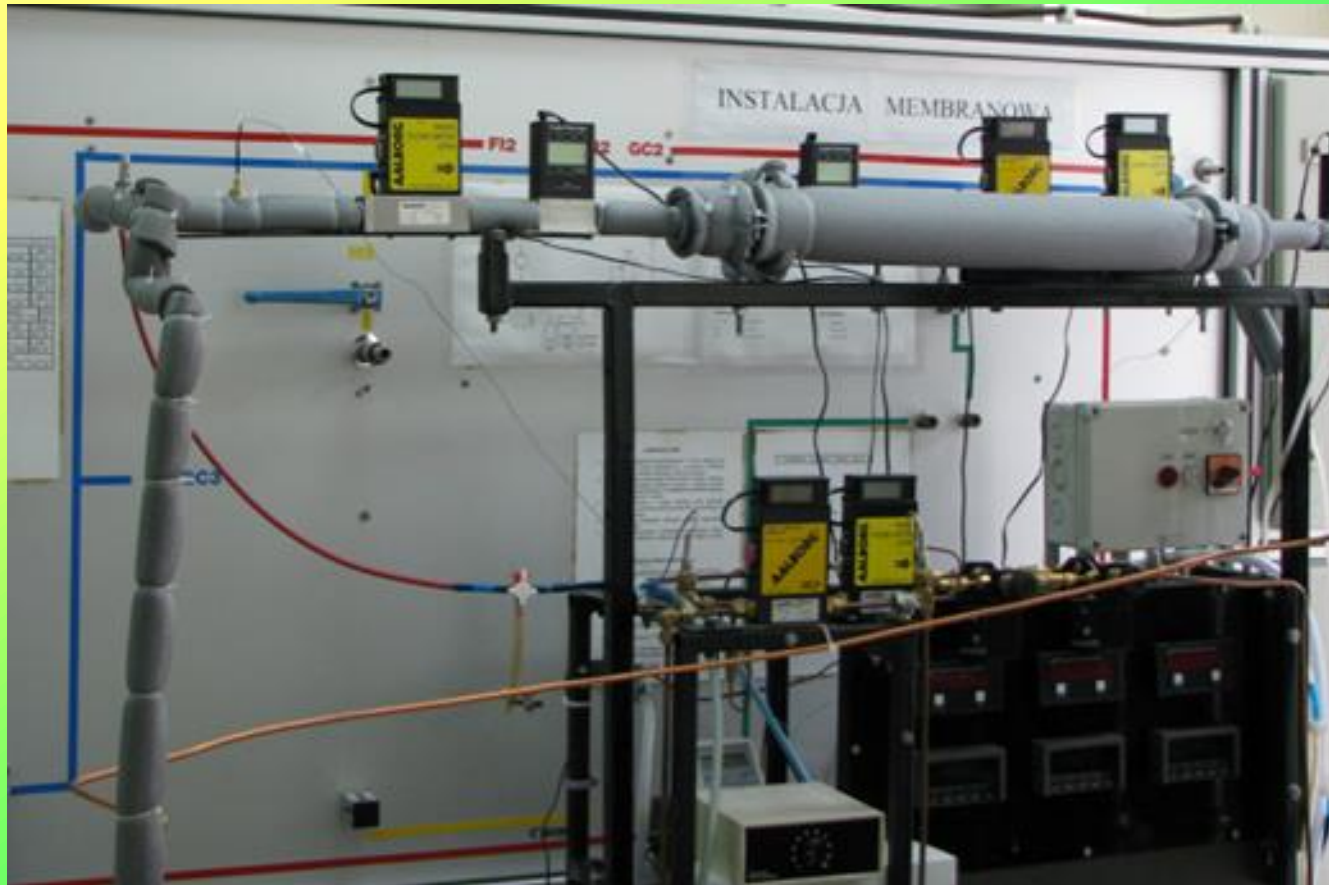
Air Products
module

$$F_P = 0.9 \text{ m}_n^3/\text{h}$$

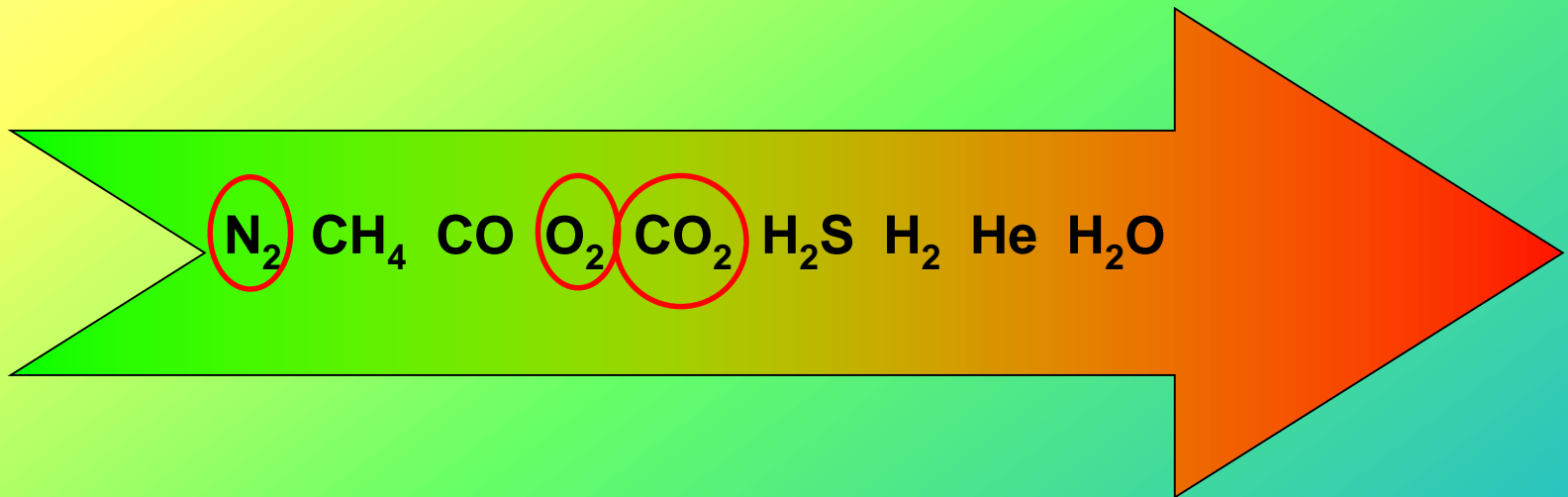


membrane unit





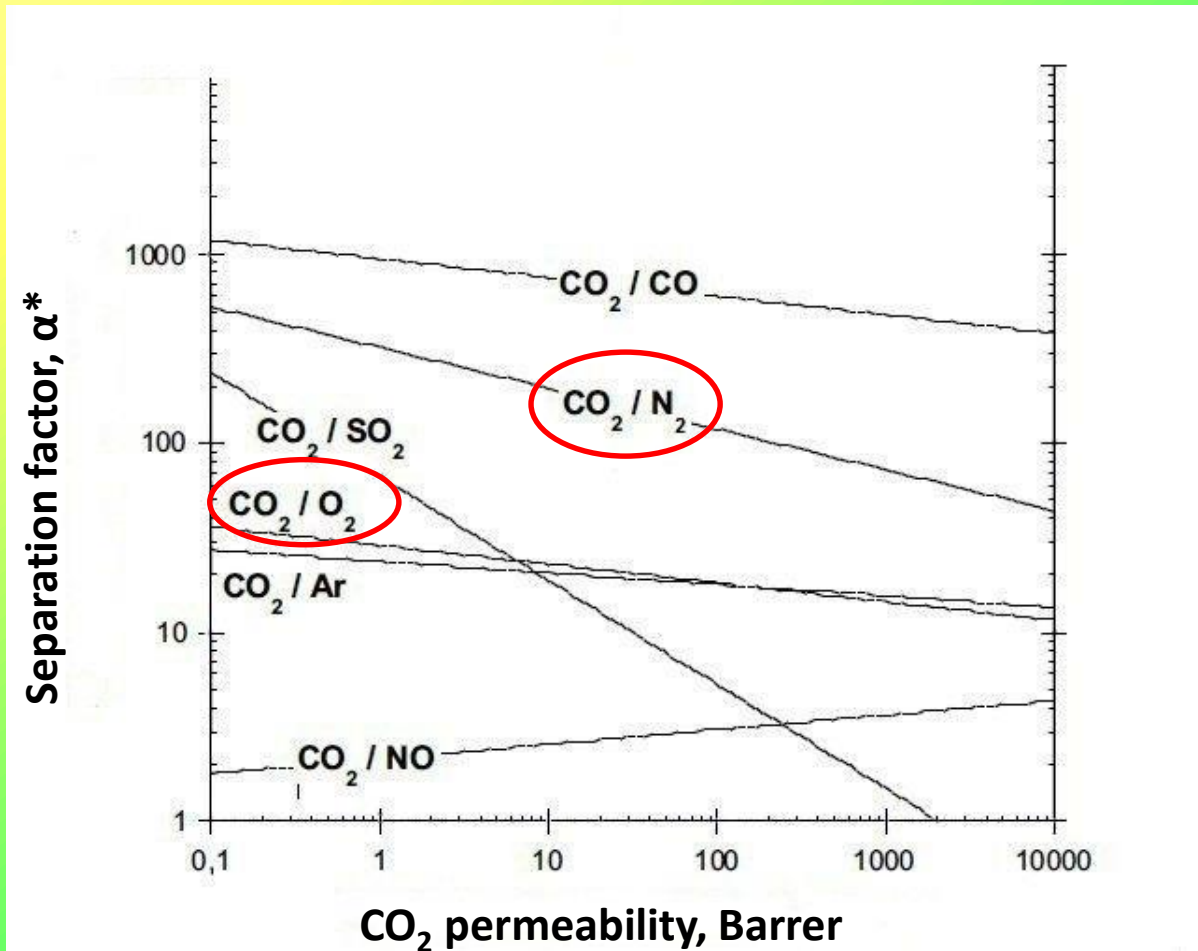
Relative permeation rates



low permeability

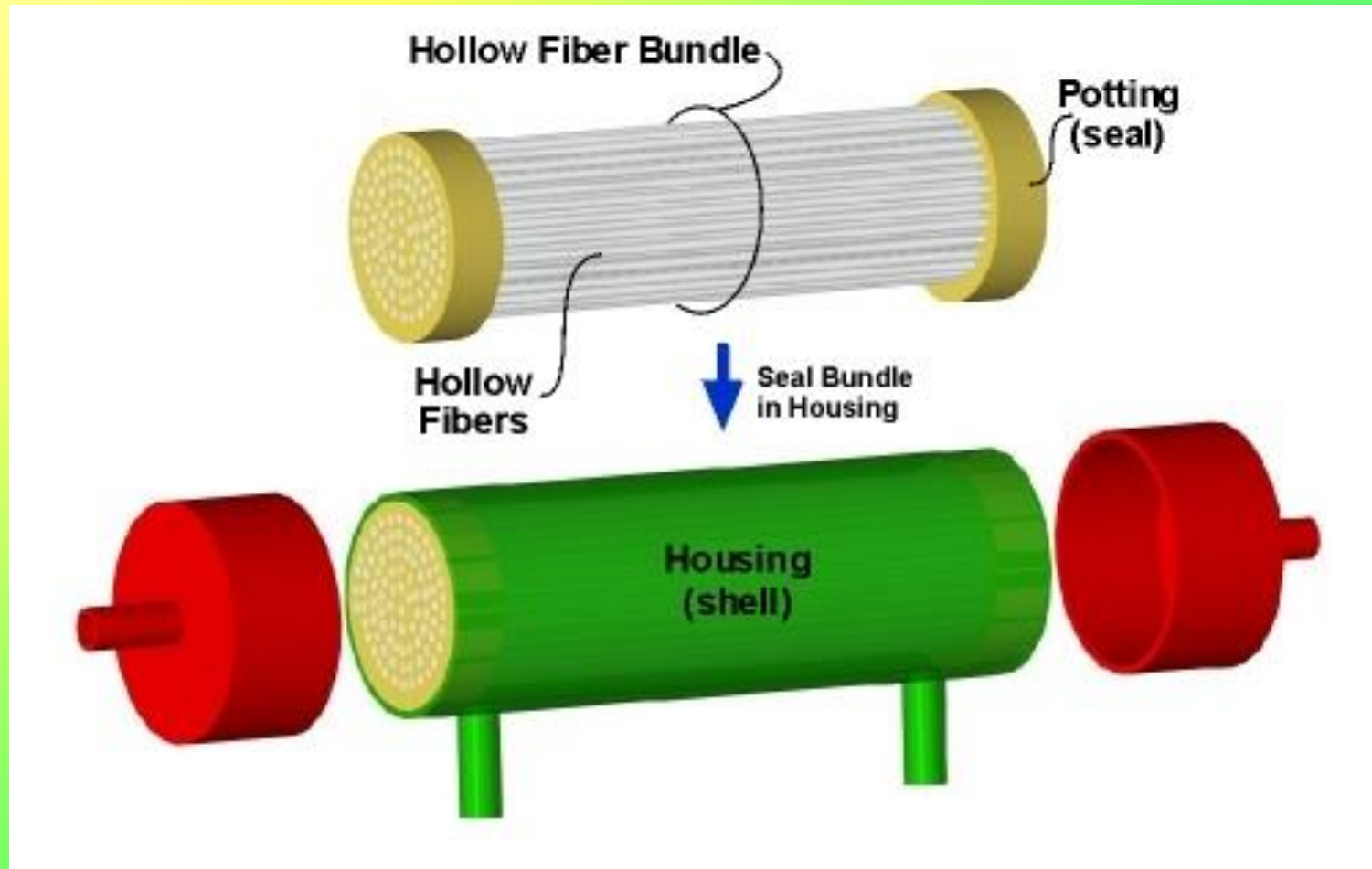
high permeability

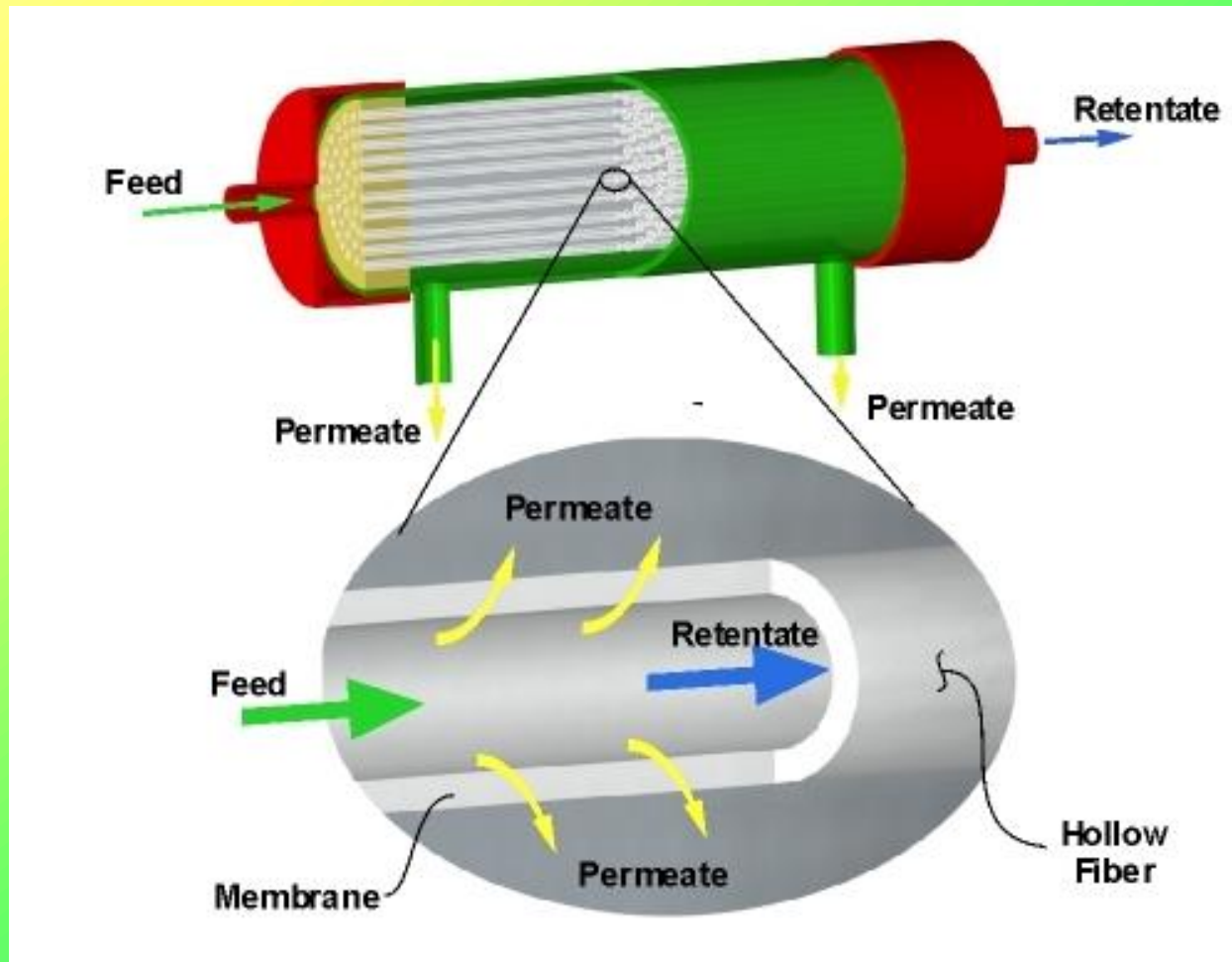


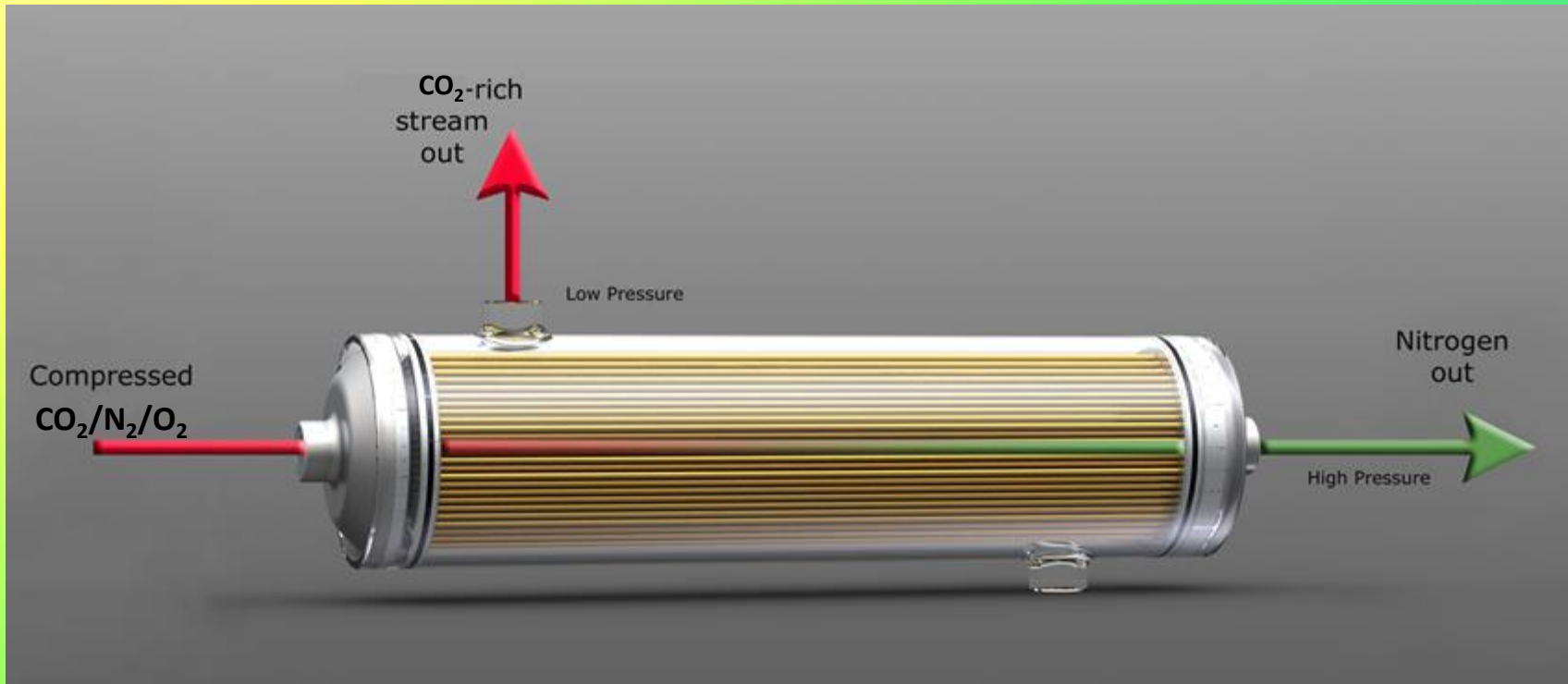


Favre E.: Membrane processes and postcombustion carbon dioxide capture: challenges and prospects. *Chemical Engineering Journal*, 171, 782-793 (2011)









Commercial hollow-fibre membrane modules



**Air Products module PRISM PA1020
(modified polysulphone)**



**UBE module CO-C05
(modified polyimide)**



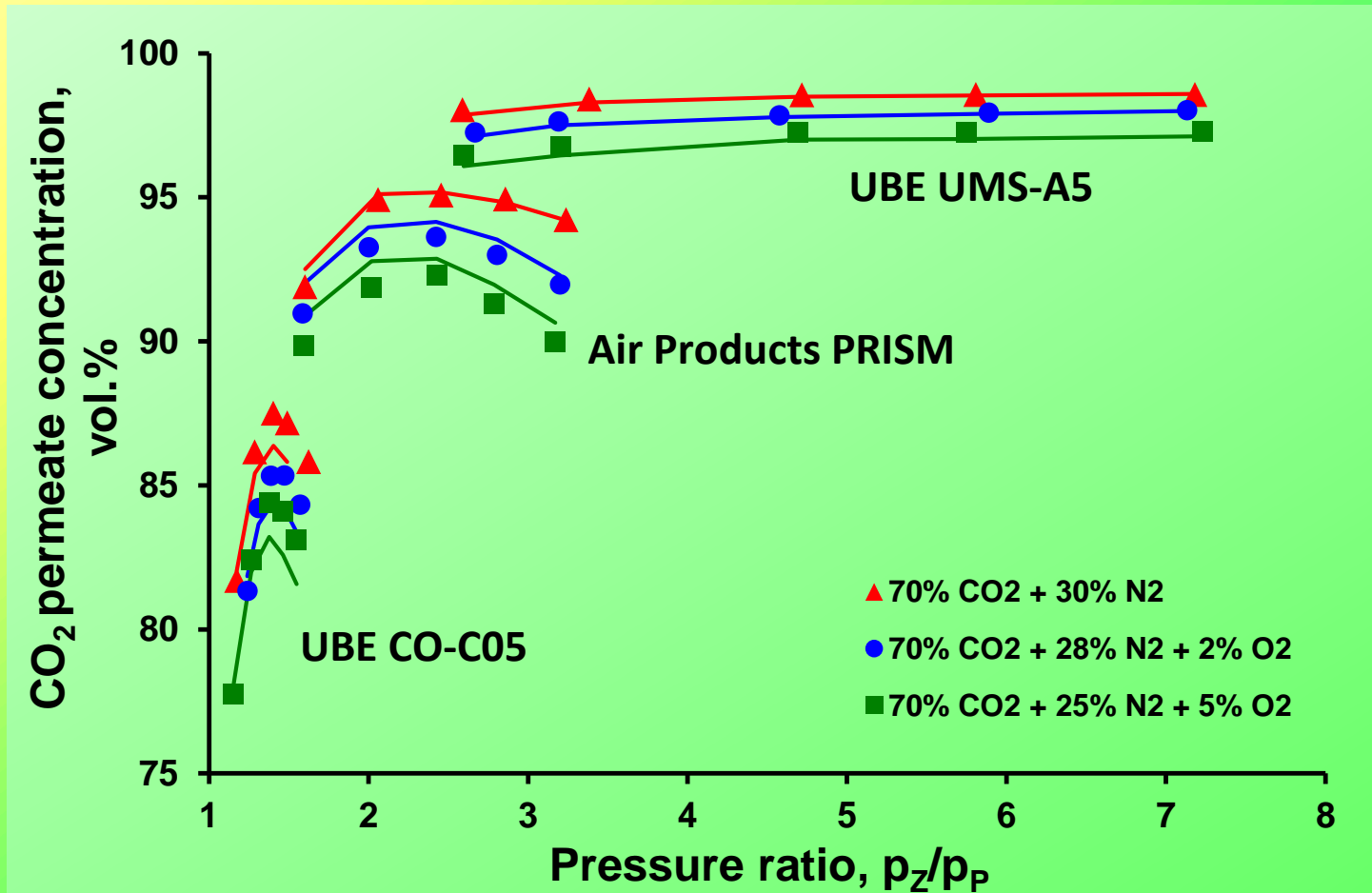
**UBE module UMS-A5
(modified polyimide)**





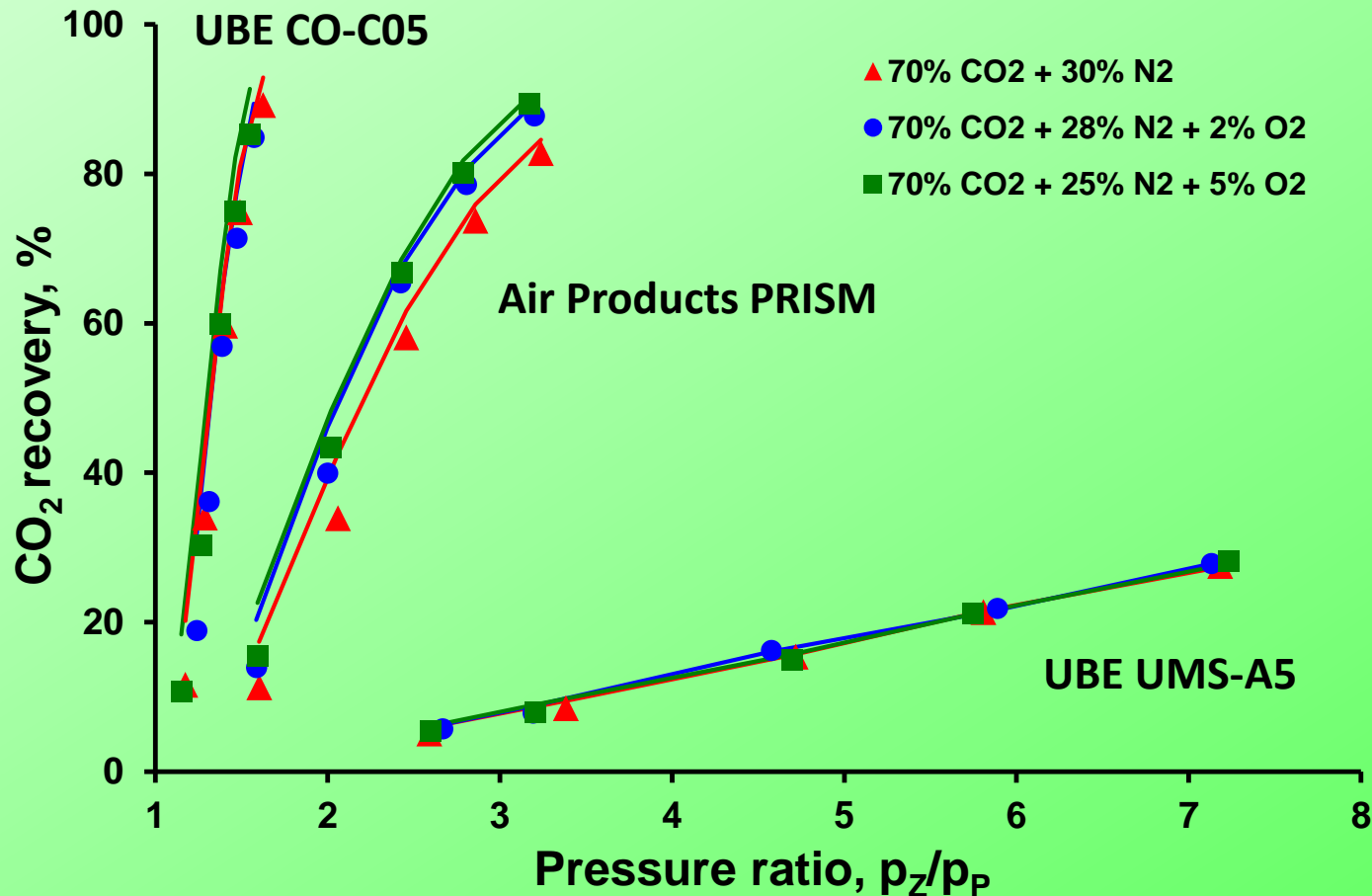
Air Products module





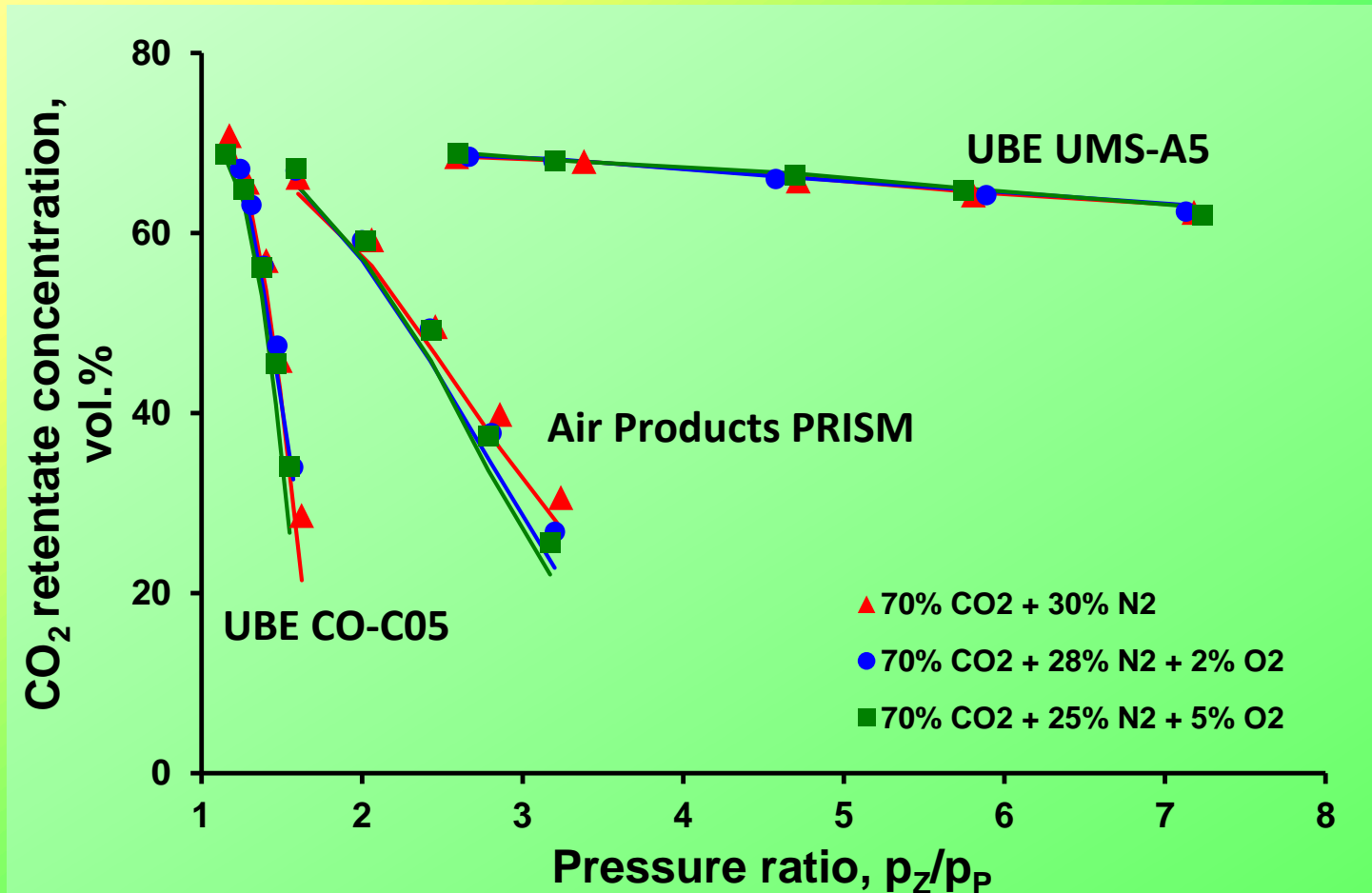
**CO₂ permeate concentration vs. pressure ratio
(symbols – experiment, lines – calculations)**





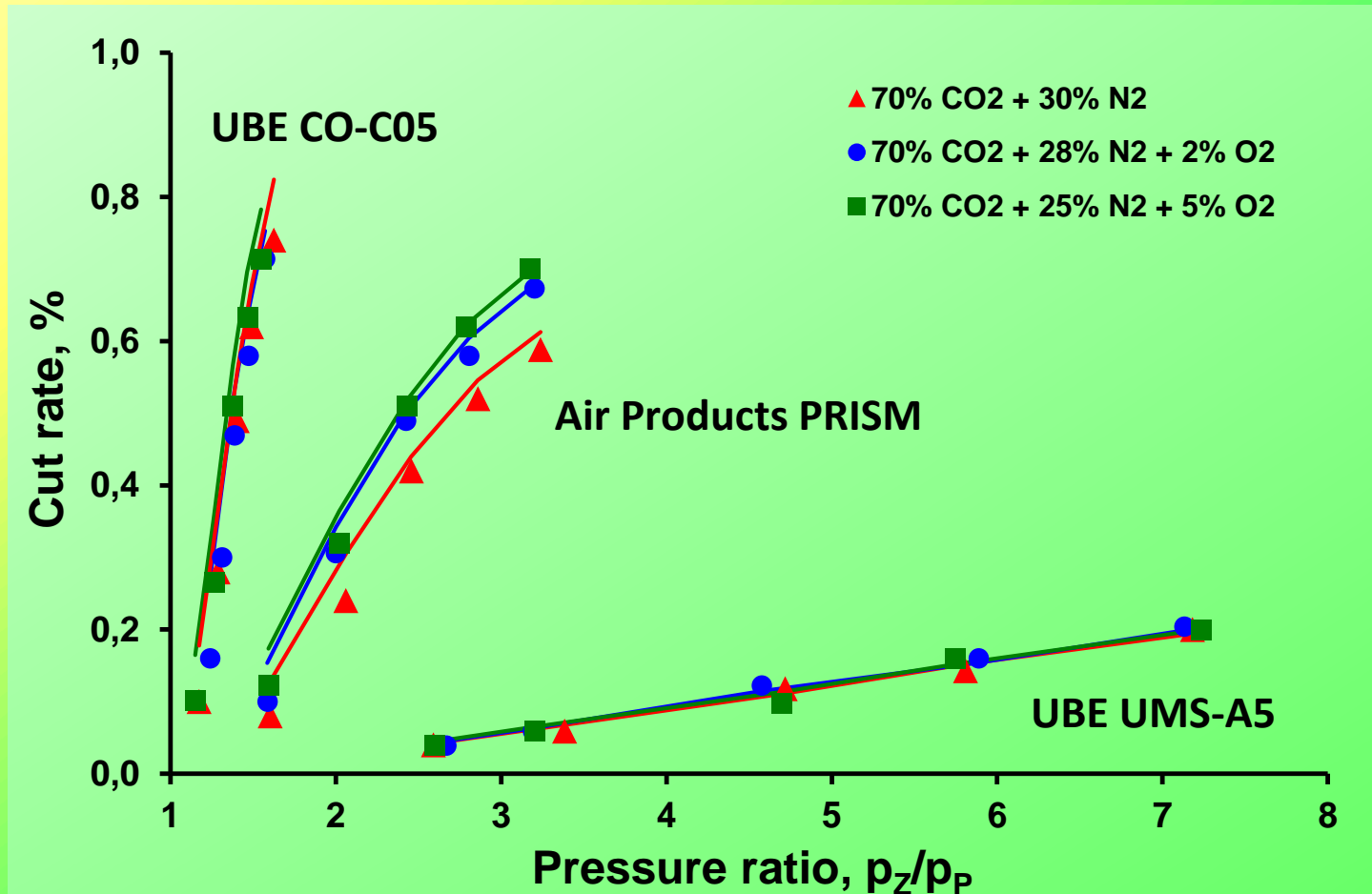
CO₂ recovery vs. pressure ratio
(symbols – experiment, lines – calculations)





**CO₂ retentate concentration vs. pressure ratio
(symbols – experiment, lines – calculations)**





**Cut rate vs. pressure ratio
(symbols – experiment, lines – calculations)**





adsorption unit separation

$$F_Z = 7.5 \text{ m}^3/\text{h}$$

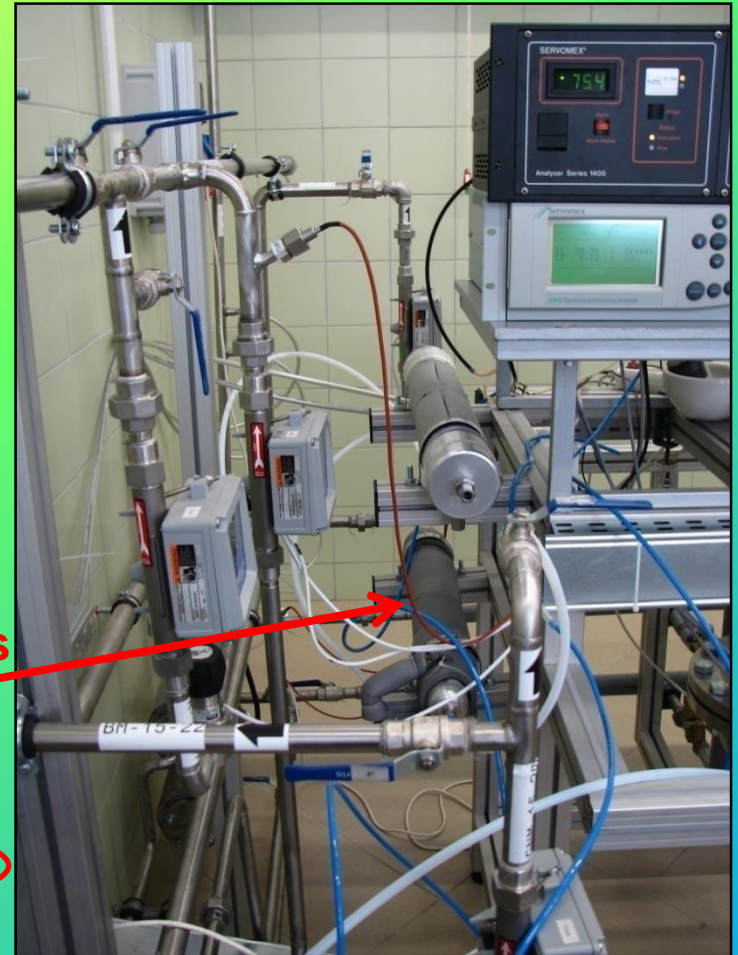
$$x_{ZCO_2} = 12.6 \text{ vol. \%}$$

Air Products
module

$$F_P = 0.9 \text{ m}^3/\text{h}$$

$$y_{PCO_2} = 96.4 \text{ vol. \%}$$

$$\eta_{CO_2} = 100\%$$



membrane unit separation



Conclusions

- The separation of ternary gas mixtures was investigated in three hollow-fibre membrane modules. In the gas stream containing 70 vol.% of CO₂ the O₂ concentration was varied between 0 and 5 vol.%
- It is found that the presence of oxygen leads to a drop in the concentration of CO₂ in the permeate for each of the commercial modules studied
- The experimental studies clearly show that, from the standpoint of the hybrid adsorptive-membrane process, the Air Products PRISM compares favourably with the other two commercial modules tested. Thus, it is this module that was selected as the final section (stage 2) of the hybrid installation, and the full-scale hybrid experiments further corroborated its usefulness. The combination of the two separation techniques produced gas streams with CO₂ content exceeding 95 vol.%; the recovery was virtually complete, as the retentate was recycled to the inlet of the hybrid installation





Thank you for your attention

