

HybSi membrane scale up on multi-channel ceramic supports for separation of H₂/CO₂ in steel industry

Mahdi Nikbakht Fini^{1*}, Raghavendra Sumbharaju¹, Marc van Tuel¹, Didier Dhaler², Yvonne van Delft¹

¹ TNO, Unit Energy Transition, Sustainable Technologies for Industrial Processes group (STIP), Petten, the Netherlands

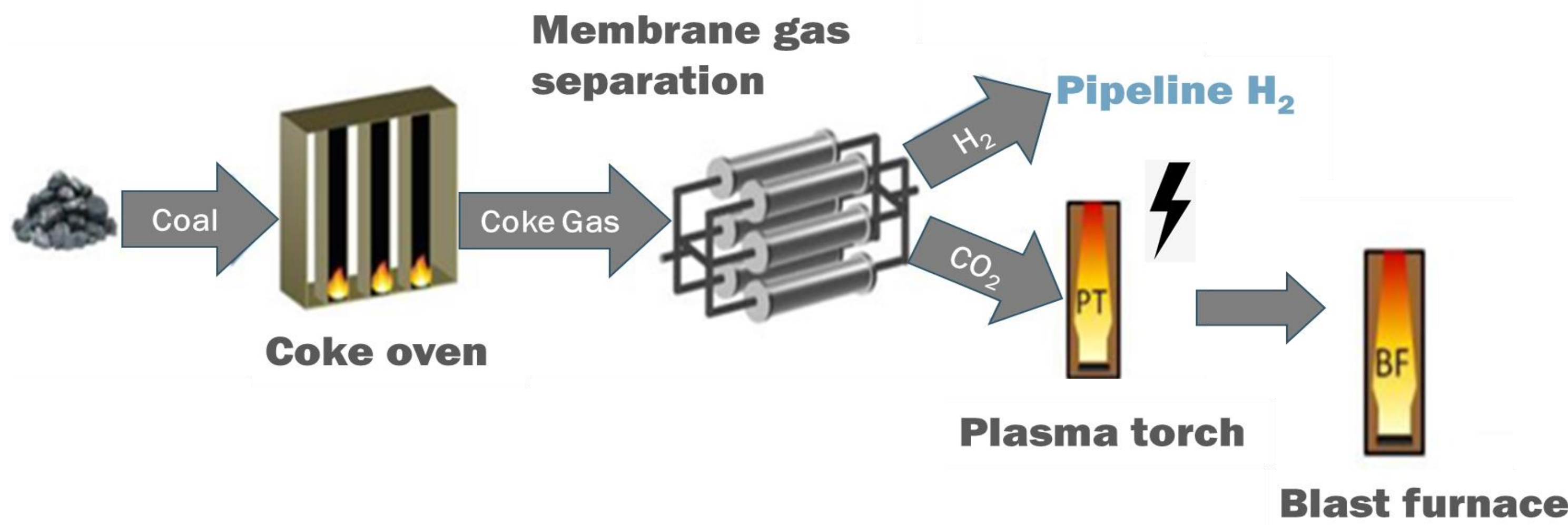
² CTI Alsys-Group, Salindres, France

*Corresponding author: mahdi.nikbakhtfini@tno.nl, + 31 6 11859746



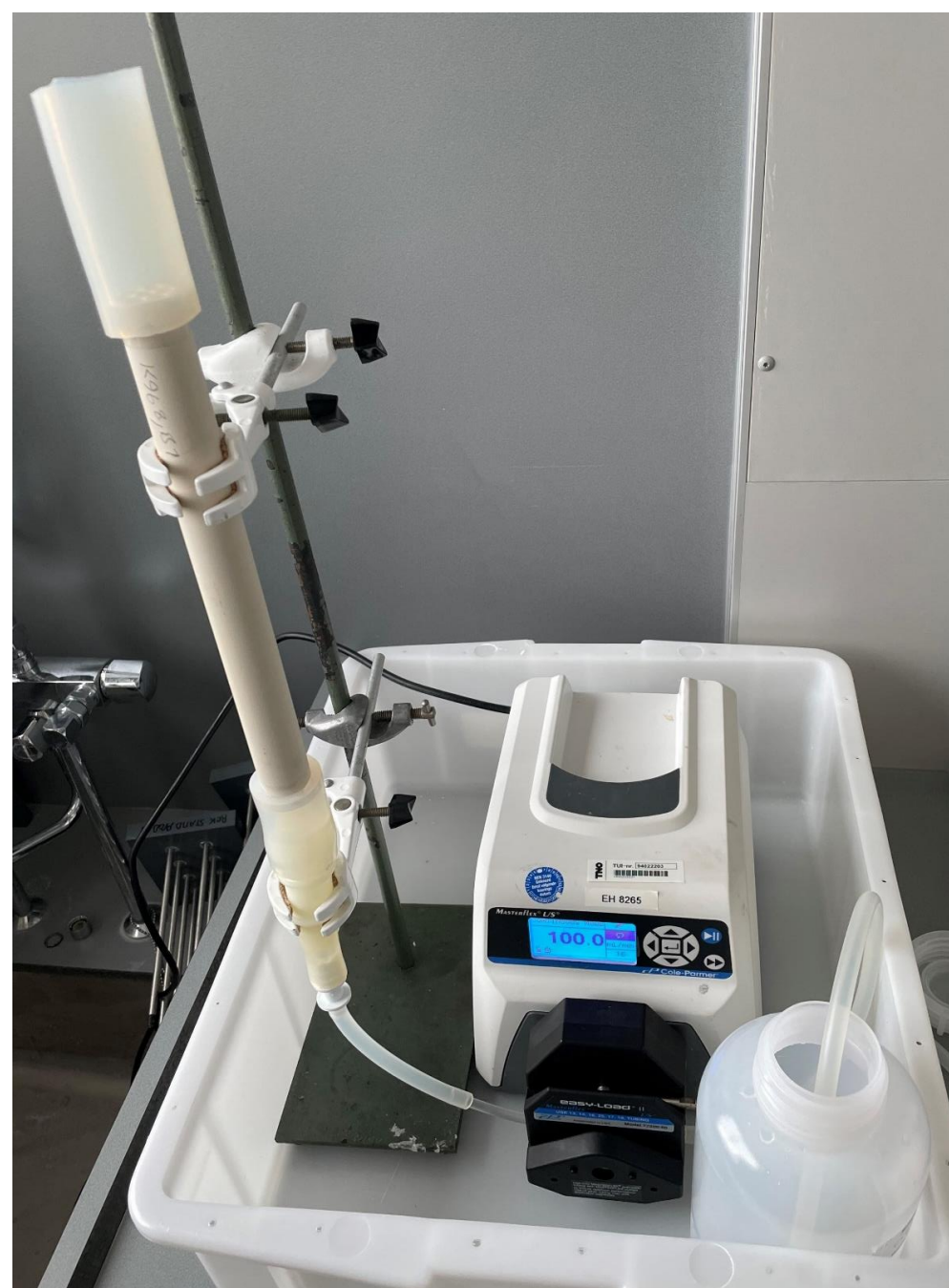
Incentive and objectives

- H₂ recovery and CO₂ capture from coke oven gas (COG) in steel industry.



Membrane preparation

- Multi-channel (7 channels) CTI 100nm ceramic support
- Membrane length: 25 cm; Channel ID: 6 mm. Membrane area: 280 cm²



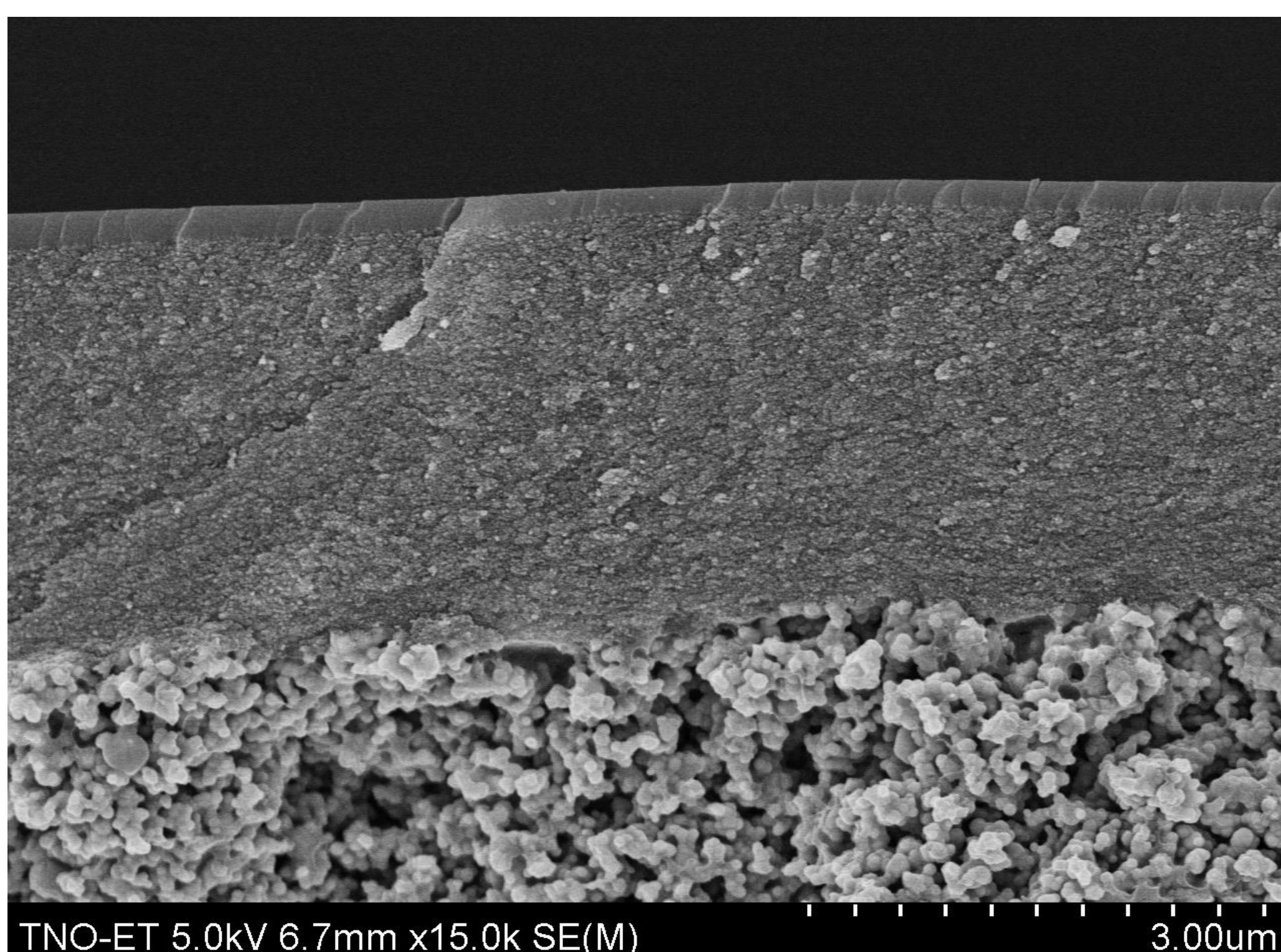
coating method

γ-alumina intermediate layer

2X diluted Boehmite solution
Heat treatment at 600 °C

Hybrid-Silica (HybSi) selective layer

Hybrid silica sol based on APTES
(3-Aminopropyl triethoxysilane)
Heat treatment at 250 °C



HybSi layer

150 nm

γ-alumina layer

CTI support

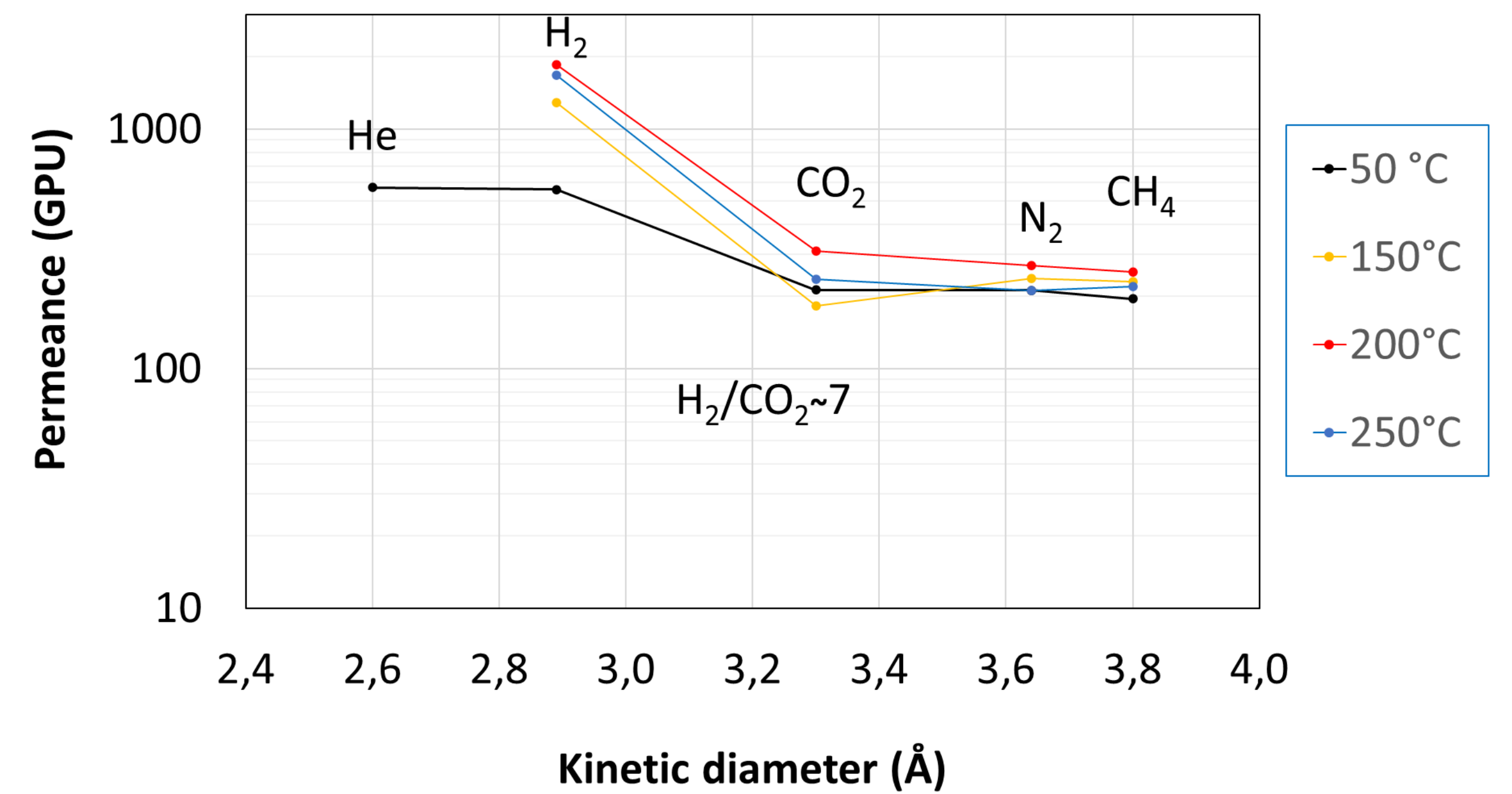
TNO-ET 5.0kV 6.7mm x15.0k SE(M)

3.00um

Results

Single gas measurements:

MC HybSi membrane, ΔP = 9 bar



- H₂ permeance in single gas measurements at 250 °C ~2000 GPU

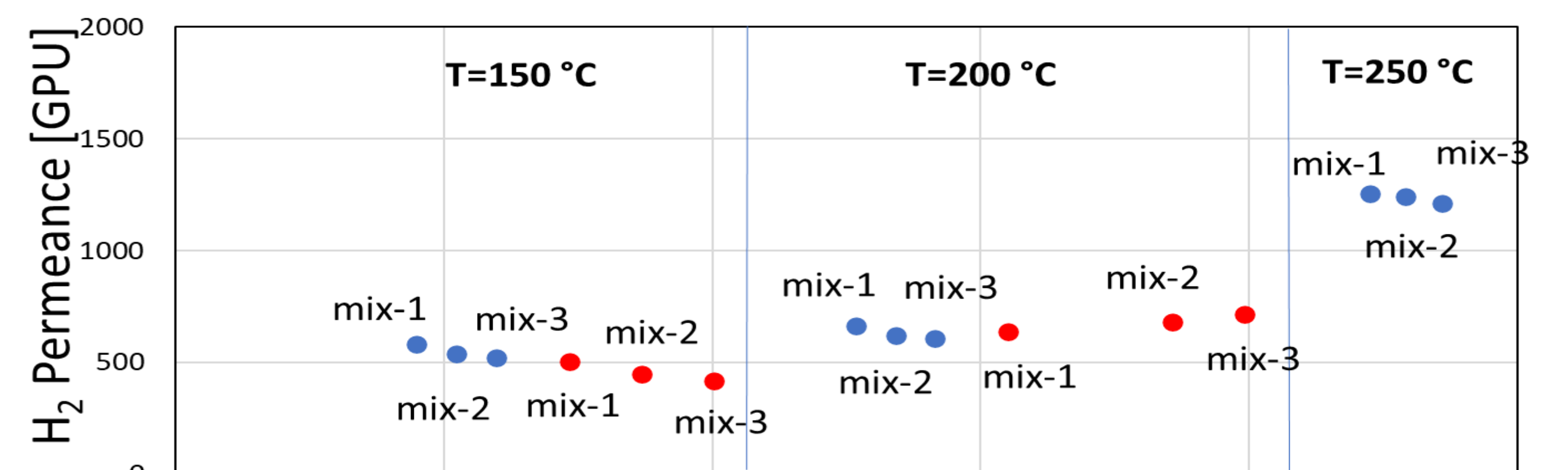
Mixed gas measurements:

- High throughput semi-pilot Gas Separation Installation at TNO
- ΔP= 9 bar
- Three gas mixtures were used:

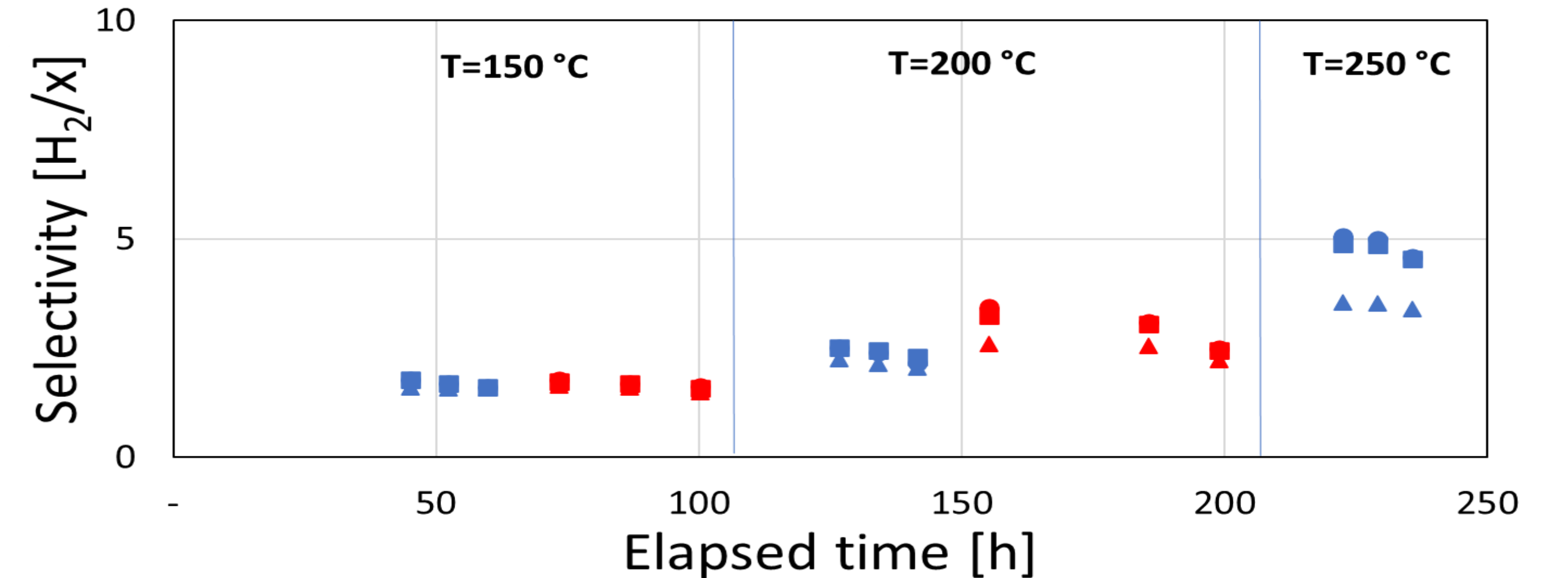
| | H ₂ | N ₂ | CO | CO ₂ | CH ₄ | H ₂ O |
|--------|----------------|----------------|----|-----------------|-----------------|------------------|
| Mix-1: | 60 | 6 | 4 | 2 | 22 | 6 |
| Mix-2: | 38 | 9,5 | 6 | 3 | 34,5 | 9 |
| Mix-3: | 16 | 13 | 8 | 4 | 47 | 12 |



Blue circles mixture composition - dry Red circles mixture composition - wet



▲ H₂/CO₂ dry ▲ H₂/CO₂ wet ● H₂/N₂ dry ● H₂/N₂ wet ■ H₂/CH₄ dry ■ H₂/CH₄ wet



- Stable performance for >250 hours
- H₂ permeance in mixed gas measurements at 250 °C ~1300 GPU
- Selectivity H₂/CO₂ ~ 4 at 250 °C

