The need for High Temperature Proton Exchange Membranes for Electrochemical Hydrogen Purification

Martijn J.J. Mulder, Peter J. Bouwman, Rombout Swanborn

HyET B.V.
Hydrogen Efficiency Technologies
Leemansweg 15
6827 BX
Arnhem
The Netherlands

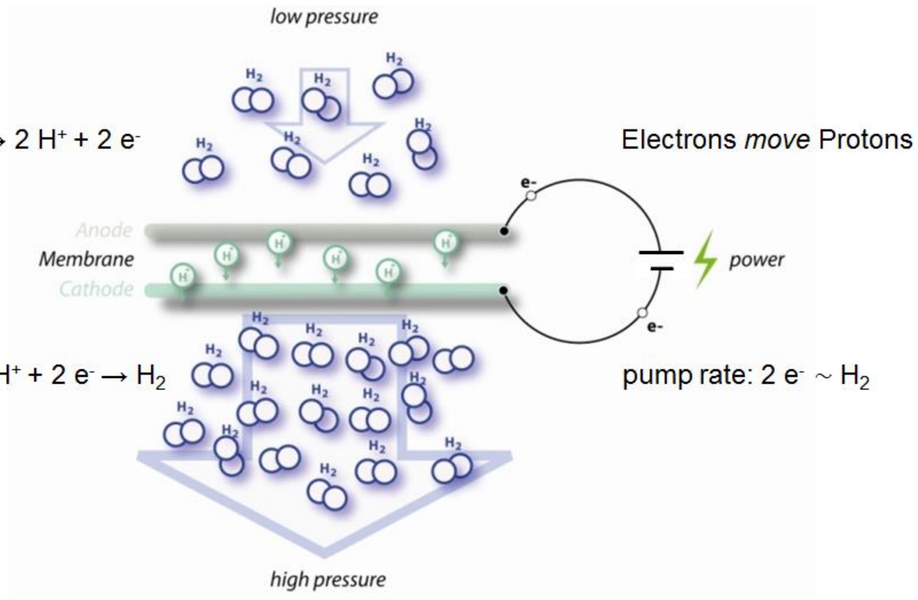
Martijn.mulder@hyet.nl

Tel: (+) 31 (0) 26 36 23 944
Mob: (+) 31 (0) 62 37 65 589
Skype: martijn.mulder53

Introduction

HyET is developing and producing electrochemical cells (Bouwman 2015) that can selectively purify (EHP) and compress hydrogen from gas mixtures.

Within project HyGrid (FCH2JU, nr. 700355, started 1 May 2016) electrochemical hydrogen extraction from a 2% H_2 in natural gas mixture is targeted.



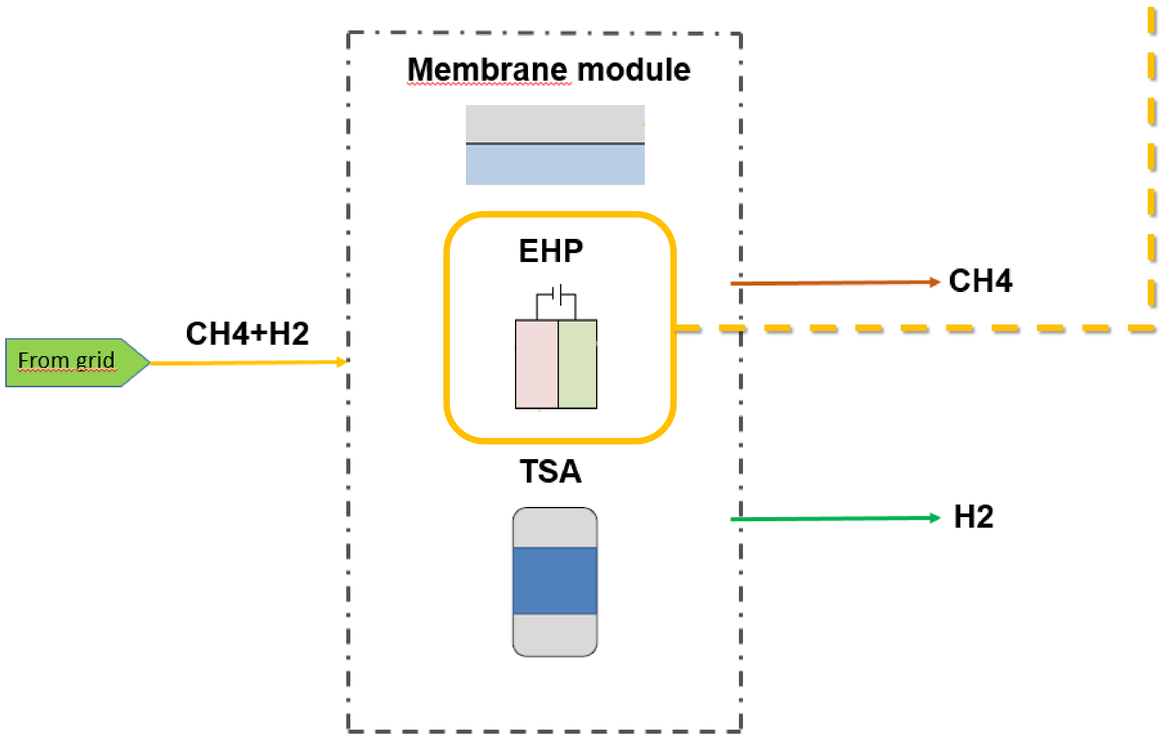
Working principle of EHP

Objectives

Design, scale-up and demonstration of a dual membrane type based system for the extraction of hydrogen from the natural gas grid as a hydrogen distribution network.

HyGrid System targets:

- Hydrogen separation system scale > 25 kg/day
- Hydrogen extraction energy < 5 kWh/kg H_2; this is < 15% of H_2 LHV of 33.33 kWh/kg H_2
- Hydrogen separation at low cost of < 1.5€/kg H_2



HyGrid hydrogen purification system scheme

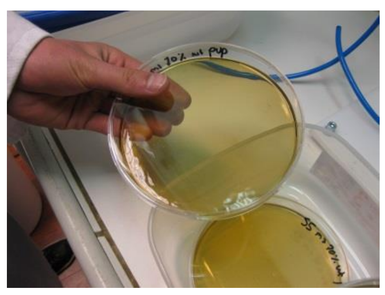
EHP unit/membrane targets:

- Recovery rate of 80% from 2% H_2 in methane
- Low/zero humidity proton conduction
- Low (hydrogen) gas permeability

Challenges

- High gas flows may cause drying out of membrane → water independent proton conduction required
- Standard HT membrane PBI/H_3PO_4 suffers from liquid acid leach out causing gas blockage and corrosion of stack components

Approach



- PBI/H_3PO_4 systems modified with additives to limit H_3PO_4 leach out
- Polymer/solid acid composites
- Covalently bonded phosphonic acid polymer membranes for T>120 deg. C operation.

Earlier EHP results on reformate

Gasses >	H_2 %	CO_2 %	CO %	CH_4 %	H_2O %
Reformate WGS premix *used as received*	70.05	19.97	7.477	2.507	
Retentate purge gas	57.6846	27.8810	10.2945	3.4483	0.692
Purified Permeate gas	99.5543	0.0188	0.0014		0.426
	99.9797 without including water				

Acknowledgements

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Bouwman, P. in PEM Electrolysis for Hydrogen Production, Principles and Applications (eds. Bessarabov, D., Wang, H., Hui, L. & Zhao, N.) Chapter 13, (2015).