

Selection of gas extractive membranes to improve hydrogen production by anaerobic digestion

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INTRODUCTION

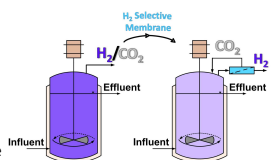
Hydrogen partial pressure (P_{H_2}) is one of the key factors affecting fermentative H_2 production and thus its continuous removal is necessary avoiding the thermodynamic limitation by the high H_2 partial pressures achieved.

Strategies to reduce P_{H_2}

- Increasing agitation
- Thermophilic conditions
- Applying a vacuum
- Gas sparging ($Ar, N_2, CO_2, Biogas$)

• H_2 Selective Membranes
 >Inorganic >Desnse
 >Polymeric >Porous

The objective was to evaluate two types of membranes (silicone and zeolite) on their separation ability of the H_2/CO_2 mixture in order to select the most suitable for selective H_2 removing produced during a conventional fermentation process.

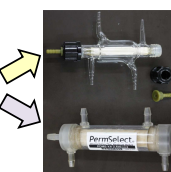
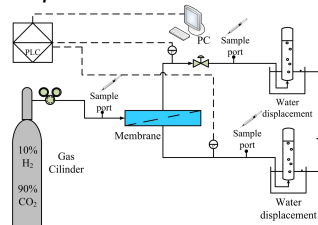


MATERIALS AND METHODS

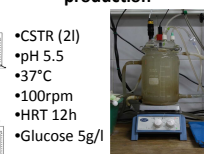
Membrane modules

Material	Configuration	Area
SAPO-34 Zeolite	Tubular	22cm ²
Silicone (PDMS)	Hollow Fiber	2500cm ²

Gas permeation tests



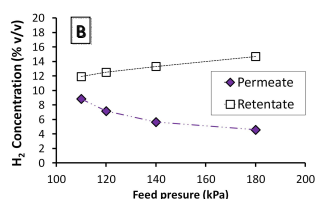
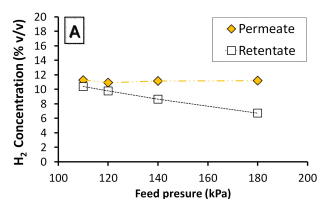
Fermentative hydrogen production



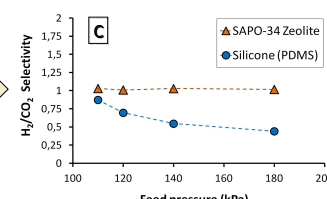
- CSTR (2l)
- pH 5.5
- 37°C
- 100rpm
- HRT 12h
- Glucose 5g/l

RESULTS

Permeation tests



$$\alpha_{H_2/CO_2} = \frac{Y_{H_2}/Y_{CO_2}}{X_{H_2}/X_{CO_2}}$$



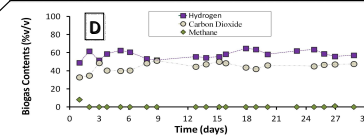
Effect of feed pressure on hydrogen composition in the permeate and retentate for SAPO-34 zeolite membrane (A) and silicone PDMS (B) membrane.

(C) Effect of feed pressure on H_2/CO_2 selectivity for the two membranes evaluated.

Fermentative H_2 production

Parameter	Average value	Units
Glucose consumption	97.3 ± 0.28	%
Volatile suspended solids (VSS)	474 ± 16	mg/L
Biogas flow	2.79 ± 0.38	ml/min
Yield	0.82 ± 0.13	mol H_2 /mol glucose

Average operating values of the anaerobic CSTR. These values were calculated where it was considered that the reactor was operating at steady state



Stable production of fermentative H_2 . (D) Biogas composition.

CONCLUSIONS

> SAPO-34 zeolite membrane did not show an appreciable degree of separation of the H_2/CO_2 mixture (10/90 vol.) under the transmembrane pressure range evaluated (10 to 80kPa). More research is necessary to find the optimal operating conditions of such membranes.

> An acidogenic fermentation producing H_2 in a stable condition was established. This conventional process had an average yield of 0.82 mol H_2 /mol.

✓ Silicone (PDMS) membrane is able to separate the mixture, leading a H_2/CO_2 selectivity of 0.44 (CO_2/H_2 selectivity of 2.27) for a transmembrane pressure of 80kPa. This allows to obtain a stream richer in H_2 in the retentate and a stream richer in CO_2 in the permeate.

Acknowledgements

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