Continuous gas drying using membrane technology

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Gas drying is an application required in many fields, such as natural gas processing, the petrochemical industries, hydrogen production, and industrial gas purification, where moisture removal is critical for process efficiency and equipment longevity. Continuous gas drying using membrane technology represents a significant advancement in separation processes. By using improved inorganic nanoporous membranes such as zeolites (NaA, SSZ-13 and SAPO-34) and carbon membranes, this technology provides superior results when compared with traditional drying methods. These membranes exhibit high selectivity and water permeances, allowing for continuous operation under varying pressure and temperature conditions with minimal maintenance (without the use of any absorbent).

Asymmetric single channel tubes made of porous α-alumina are used as a support for zeolite membranes, which are synthesized via hydrothermal crystallization and calcination, typically reaching 1 to 2 µm in thickness. Carbon membranes, on the other hand, are produced through dip-coating, drying, crosslinking, and pyrolysis, resulting in thicknesses of 200 to 1000 nm. The membranes were characterized with FESEM and XRD to evaluate their separation performance properties through gas permeation measurements in different conditions. In this case, the evaluation was investigated using H_2O/H_2 (water/hydrogen) and H_2O/CH_4 (water/methane) separation measurements at a feed pressure of 10 barg and a temperature of 50 °C for zeolite, 120 °C for carbon membranes (Fig. 1).

Fig. 1: Conditions of measurement for the separation of water steam from H_2 and CH_4.

Parameter	H_2O/H_2	H_2O/CH_4
Feed pressure [barg]	10	10
Permeate pressure [barg]	0	0
Measuring temperature [°C]	50, *120	50, *120
Stream percentage [%]	4	4.65
Gas flow rate [Nl/h]	180	153
H_2O mass flow [g/h]	6	6

* Measurement conditions for the carbon membrane

When considering the H_2O/H_2 separation (Fig. 2), the carbon membrane performs weakest with a selectivity of 10 and a H_2 permeance of 1750 [l/(m²·h·bar)]. While the zeolite membranes SAPO-34 and SSZ-13 showed a comparable H_2O permeance between 2500 and 3000 [l/(m²·h·bar)], the SSZ-13 membrane achieved a higher H_2O/H_2 selectivity of ~ 16. In contrast, the NaA membrane showed the highest H_2O/H_4 selectivity (67) at a H_2O permeance of 3250 [l/(m²·h·bar)]. With the H_2O/CH_4 separation, the selectivities were generally higher. The SAPO-34 membrane has a relatively low H_2O permeance and H_2O/CH_4 selectivity. The SSZ-13 membrane showed a balanced ratio between permeance and selectivity. The NaA membrane, on the other hand, is characterized by a high H_2O/CH_4 selectivity of > 100 and an H_2O permeance (~ 3200 [l/(m²·h·bar)]), which makes it a promising candidate for efficient gas drying applications. Even better values were achieved with the carbon membrane. The H_2O/CH_4 selectivity exceeded 1000 with a permeance of ~ 3600 [l/(m²·h·bar)]. Carbon membranes thus show excellent potential for direct biogas drying, while zeolite membranes (NaA) are promising candidates for hydrogen drying.

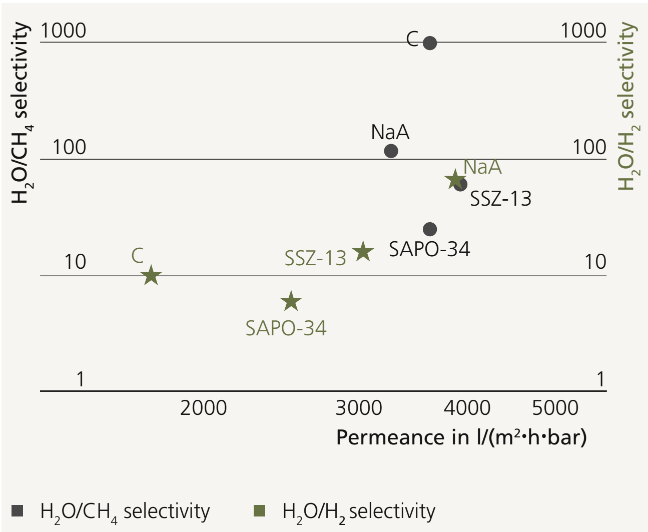

Fig. 2: Performance of different zeolite and carbon membranes for H_2O/H_2 and H_2O/CH_4 separation.

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