Membrane reactor with thin Pd-alloy supported membrane for syngas upgrading

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MEMBRANE REACTOR WITH THIN PD-ALLOY SUPPORTED MEMBRANE FOR SYNGAS UPGRADING

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**Presenting author:** Giuseppe Barbieri  
**Authors and affiliations:** Giuseppe Barbieri: ITM-CNR, Rende, Italy | Adele Brunetti: ITM-CNR, Rende, Italy | Alessio Caravella: DIATIC, UNICAL, Rende, Italy | Ekain Fernandez: Energy and Environment Division, TECNALIA, San Sebastián-Donostia, Spain | David Alfredo Pacheco Tanaka: Energy and Environment Division, TECNALIA, San Sebastián-Donostia, Spain | Fausto Gallucci: Chemical Process Intensification, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology, Eindhoven, Netherlands | Enrico Drioli: ITM-CNR, Rende, Italy | José Luis Viviente: Energy and Environment Division, TECNALIA, San Sebastián-Donostia, Spain

**Abstract:**
In the hydrogen production cycle, the syngas streams produced by reformers and/or coal gasification plants contain a large amount of H2 and CO that need to be upgraded. To this purpose, membrane reactors using Pd-based membranes have been largely studied as they allow separation and recovery of a pure hydrogen stream in the permeate side. However, one of the main limitations for scaling up this technology is the high cost of the Pd-membranes. Therefore, many researchers are now pursuing the possibility to use supported membranes with Pd-alloy layers as thinner as possible.

In this work, the upgrading of a syngas stream was experimentally and theoretically investigated in a WGS Pd-based membrane reactor (MR) operated in the high temperature range by using an ultra-thin supported membrane (4 micron-thick). The membrane permeance was measured before and after catalyst packing and after reaction (in a total of 2100 h of operation).
The performance of MR was evaluated as a function of operating conditions like temperature, pressure, GHSV, feed molar ratio, sweep gas for various configurations.

At each temperature investigated, MR showed good performance in terms of both CO conversion and hydrogen recovery (CO conversion = 96% and H2 recovery=84%@ 2500 h⁻¹, 400°C, 4 bar) exceeding the traditional reactor equilibrium conversion up to 10700 h⁻¹ in the whole range of the feed pressure considered.

The use of sweep gas was found to further promote the reactor performance, improving the CO conversion of around 16% with respect to the case without sweep gas and gaining a hydrogen recovery of an additional 28%, passing from 52% to 74%. The positive effect of the temperature on permeation and kinetics, contrasting with its negative effect on the thermodynamics, was clearly evident in terms of recovery, which increased from 40% (at 360°C) up to 78% (at 400°C) at 4500 h⁻¹. A similar increase occurred at 10070 h⁻¹, at which the recovery at 400°C was double with respect to that at 360°C.

The advantage offered by MR was quantified also in terms of Volume Index. In fact, at 5 bar, the MR required a reaction volume of 15% of that traditional reactor operated in the same conditions. However, already at 3 bar, the Volume Index was still 30%, which means in other words that a flow rate three times higher than that considered for TR could be treated to achieve the same conversion as that of TR using the same amount of catalyst.

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**Reference 1:**
**Reference 2:**
**Reference 3:**
**Reference 4:**

**Highlight 1:** Upgrading of a syngas stream by thin Pd-Ag membrane reactor (4 micron-thick)