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Attrition-resistant membranes for fluidized-bed membrane reactors: double-skin membranes

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ABSTRACT

Pd-Ag supported membranes have been prepared by coating a ceramic interdiffusion barrier onto a Hastelloy X (0.2 μm media grade) porous support followed by deposition of the hydrogen selective Pd-Ag (4-5 μm) layer by electroless plating. To one of the membranes an additional porous Al_2O_3-YSZ layer (protective layer with 50 wt% of YSZ) was deposited by dip-coating followed by calcination at 550 °C on top of the Pd-Ag layer, and this membrane is referred to as a double-skin membrane. Both membranes were integrated at the same time in a single reactor in order to assess and compare the performance of both membranes under identical conditions. The membranes have first been tested in an empty reactor with pure gases (H_2 and N_2) and afterwards in the presence of a catalyst (rhodium onto promoted alumina) fluidized in the bubbling regime. The membranes immersed in the bubbling bed were tested at 400 °C and 500 °C for 115 and 500 hours, respectively. The effect of the protective layer on the permeation properties and stability of the membranes were studied. The double-skinned membraned showed a H_2 permeance of $1.55 \cdot 10^{-6}$ mol m^{-2} s^{-1} Pa^{-1} at 500 °C and 4 bar of pressure difference with an ideal perm-selectivity virtually infinite before incorporation of particles. This selectivity did not decay during the long term test under fluidization with catalyst particles.

Graphical abstract: