Fabrication & Performance Study of Pd-Au PSS Supported Membrane Reactor Via Natural Gas Steam Reforming

Bryce Anzelmo[1], Simona Liguori[1], Ivan Mardilovich[2], Yi-Hua Ma[2], Jennifer Wilcox[1]

[1]Department of Energy Resources Engineering, Stanford University, Stanford, CA
[2]Department of Chemical Engineering, Worcester Polytechnic Institute, Worcester, MA

One possible use for hydrogen, without direct greenhouse gas emissions, is as feed for a fuel cell (FC), with the most readily available technology being a proton exchange membrane FC (PEMFC). In order to avoid poisoning the PEMFC's Pt-based catalyst due to the presence of ppm levels of CO, the hydrogen feed needs to be ultra-pure. The industrial process for hydrogen production, which is a multi-step energy intensive process followed by further separation/purification, can be a potential source [1]. However, as an alternative method a Pd-based membrane reactor (MR) can be used owing to its ability to provide the pure hydrogen without any further separation/purification step. Moreover, the MR works at milder operating conditions compared to the traditional system.

In recent years, Pd-based composite membranes, i.e., thin metallic layer supported on porous materials such as ceramics or stainless steel, have been considered due to their lower cost (thin Pd layer) and higher mechanical strength (porous support) compared to dense Pd-based ones [2]. Moreover, the use of Pd-alloys, in particular, with Ag, Au, Pt, has grown in the last years given their ability to resist sulfur poisoning with increased hydrogen permeability [3]; therefore, the aim of this study is to fabricate a Pd-Au membrane supported on porous stainless steel (PSS) and evaluate its performance in a MR with the intent to produce pure hydrogen from natural gas steam reforming.

The membrane in this study was fabricated via an electroless plating technique for depositing Pd and electro-plating for Au. The steps for fabricating this membrane are described in the following steps: 1) abrasive sanding to obtain a smooth Zr surface 2) electroless plating of Pd 3) another electroless plating of Pd 4) electroplating of Au 5) final eletroless plating of Pd [4-8]. Each fabrication step provides a benefit relating to pore size reduction, which mitigates the defects of the support. Moreover, the initial Zr layer not only mitigates pore size, but also provides an intermediate layer that limits the intermetallic diffusion. This multistep process allows for realizing a membrane characterized by a Pd-Au layer of ~ 12 μm with 4.4 wt% Au content (Fig. 1). At each step of the fabrication process, permeation tests with

pure He are carried out, at room temperature and pressure difference of 1 bar . Fig. 2 shows the results of the permeation tests in which it is evident the progression and reduction of He flux during the membrane fabrication process.

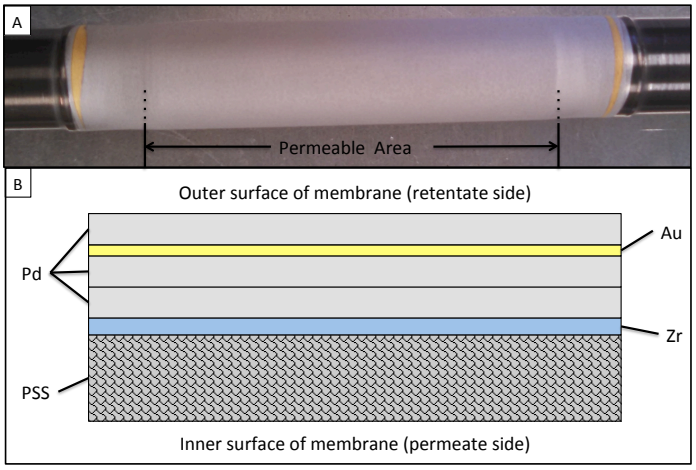


Fig. 1. Pd-Au PSS composite membrane: [A] Picture of completed membrane [B] Detailed schematic of completed metallic membrane.

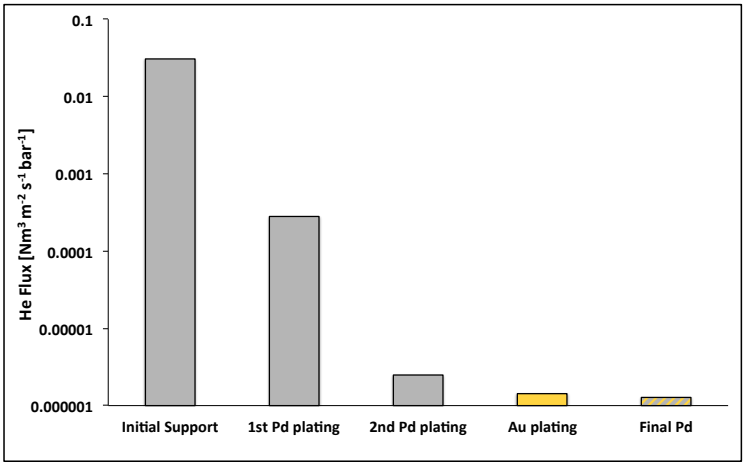


Fig. 2. Helium permeating flux during membrane progress, ΔP = 1bar, T = 25°C.

The initial characterization of the membrane by way of ideal selectivity took place at 400°C with H_2, He and Ar with ΔP in the range of 0.5 - 3.0 bar. After ideal selectivity characterization of the Pd-Au/PSS membrane, natural gas steam reforming reaction testing is carried out and the MR performance in terms of natural gas conversion, hydrogen production and hydrogen permeate purity is analyzed and discussed.

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