# Palladium-composite membrane application for the separation of high-purity hydrogen from gas mixtures

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Hydrogen is a clean and efficient energy carrier, and the hydrogen economy is currently seen as a potential solution for energy security. Therefore, the extraction and purification of hydrogen from gas mixtures is an extremely relevant issue. Membrane technology serves as the most effective and economically viable alternative for the extraction of high-purity hydrogen.

Various hydrogen-selective membranes can be represented by carbon molecular sieves, dense metallic, silicon oxide, polymer, and composite membranes. The main drawbacks of commercial membrane samples include high cost and low performance, which makes composite membranes consisting of a permeable substrate and a coated selective palladium layer of great scientific and practical interest. A properly chosen support and an optimal Pd active layer will achieve high selectivity and significant permeability for effective gas separation.

The active palladium layer applied to the support gives selectivity to the material. This layer should be as thin as possible, while also being gas-tight with minimal defects. Various methods are used for deposition, including magnetron sputtering, chemical vapor deposition, electroplating, and others.

Porous Vycor glass, metal substrates, polymers, and ceramics are used as supports for composite membranes. The permeability of the support and the thickness of the selective layer influence the membrane's performance.

In the present work, laboratory methods have been developed for synthesizing composite membranes based on a porous ceramic substrate with varying pore diameters in the range of 50-150 nm from anodized aluminum oxide with a palladium layer. The use of anodized aluminum oxide as a support determined the mechanical and thermal stability of the material, as well as the ability to control geometric parameters (pore diameter and spacing between their centers) during anodization. The authors established that by varying the voltage, electrolyte composition, concentration, and temperature, the porous structure of the ceramic substrate can be regulated. The application of the palladium active layer through vacuum and magnetron sputtering ensured the selectivity of the composite membrane. The authors highlight the exceptional importance of nanofibers in the pores of the ceramic substrate, as they promote adhesion and retention of the deposited selective layer on the surface of the anodized aluminum oxide.

The obtained composite membranes have successfully passed laboratory tests for determining the gas permeability of composite membranes using model mixtures of H2/N2, and tests are currently being conducted on real gas mixtures containing CO and CO2. Positive research results showed that the developed prototypes of composite membranes based on a porous ceramic substrate hold promise for future use in technologies for the extraction of pure hydrogen.

The research group continues to optimize the technology for producing composite membranes and is testing new methods for creating the selective layer, with the aim of developing a prototype that will occupy its niche in the hydrogen technologies of the future.