PREPARATION AND GAS SEPARATION PERFORMANCE EVALUATION OF IN-HOUSE MIXED MATRIX MEMBRANES AND METALLIC MEMBRANES DEVELOPED ON 3D-PRINTED SUBSTRATES

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ABSTRACT

To achieve the objectives of the European Green Deal and meet the demands of addressing climate change, severe measures must be implemented to mitigate emissions originating from various sectors such as transportation, industry, and energy. Carbon dioxide (CO_2) capture and renewable hydrogen production are considered crucial strategies for hard-to-decarbonize sectors.

Membrane-based separation processes offer distinct advantages for small to medium-scale and decentralized applications compared to conventional methods. They are anticipated to play a pivotal role in the CO_2 capture process [1] due to their low environmental impact and ease of scaling up. Additionally, these processes can be effectively employed for extracting hydrogen from renewable sources like green ammonia.

Various membrane materials, including common polymers, microporous inorganic, and metallic or mixed matrix membranes (MMMs), have been proposed for diverse gas separation processes. Each material type exhibits unique separation properties, thermal and chemical stability, and mechanical strength. Typically, polymer membranes demonstrate good separation performance, are cost-effective for large-area module fabrication, but may have reduced stability when exposed to acid gases or adverse conditions. However, inorganic membranes, such as metallic and ceramic, can theoretically operate in adverse conditions, although the consistent production of large defect-free membranes remains a challenge [2-4].

The current study focuses on the preparation and gas separation performance evaluation of various membranes. Polyimide membranes were synthesized by incorporating various zeolites into polymeric matrix through wet chemistry routes. Additionally, metallic membranes were prepared using 3D-printed substrates (Selective Laser Melting, SLM, method) onto which thin films of Pd and/or Ag were deposited through electroless plating [2-6] (i.e. activation with $SnCl_2$ solution and Pd salt solution and treatment with a solution of $Pd(NH_3)_4(NO_3)_2$ [6]). Commercial ceramic substrates were similarly treated, as a reference case. All membranes were evaluated in terms of gas permeability and ideal selectivity, specifically targeting applications like CO_2/N_2 (polymeric) and H_2/N_2 (metallic) separations, in a lab scale constant volume experimental unit [5]. Promising results were obtained for zeolite Na-ZSM5 incorporated in PI after 48 hrs of drying, while the thickness and homogeneity of Pd films onto the 3D printed metallic substrates appears to affect the performance in selectivity.

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KEYWORDS: Mixed Matrix Membranes, Polyimeric Membranes, Pd-based Metallic Membranes, Gas Separation

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