METALLIC MEMBRANES AND N_2 SEPARATION

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High permeability, high selectivity and good mechanical/chemical resistance are the four important characteristics required for a commercial gas separating membranes. Nevertheless, the development of membranes able to show both high permeability and selectivity is still in progress. On this route, metallic membranes seem to offer improved performance compared to polymeric membranes. The aim of this work is to explore the potential of metallic membranes for N_2 separation. In particular, the effect of different temperature and pressure conditions as well as the effect of different gas exposure on membrane performance, in terms of N_2 permeating flux and ideal selectivity of N_2 with respect to another gas is studied and analyzed. Moreover, scanning electron microscopy (SEM), and an electron microprobe analyzer (EMPA) are used for investigating the effect of the different operating conditions on the membrane surface.

Based on a preliminary theoretical investigation using density functional theory, the Group V transition metals (e.g., vanadium (V), niobium (Nb) and tantalum (Ta)) show strong affinity toward N_2. Moreover, from solubility and diffusivity values taken from the literature, iron (Fe) seems to be a good fit for this application; therefore, these metals are chosen as membrane materials in this study and in particular, pure V, Nb, Ta and Fe foils with a thickness of 40 μm have been investigated.

Permeation tests with pure gases (He, N_2, CO_2 and CH_4) are performed to characterize the membranes in terms of the N_2 permeating flux and ideal selectivity at different temperature and pressure conditions, which vary from 400 to 600 °C and from 2.0 to 60 bar, respectively. From the experimental results, all of the membranes show infinite selectivity towards N_2 separation at each operating condition tested. V shows better performance in term of the N_2 permeating flux compared to Nb, Ta and Fe.

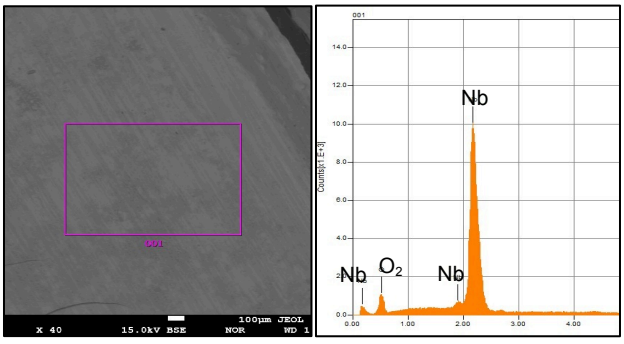


Figure 1 – EMPA analysis after tests – Nb membrane

Nb and Ta are completely destroyed when the temperature is raised from 400 to 500 °C. EMPA analysis on these membranes has shown the presence of oxygen on the surface, as illustrated in *Figure 1* where EMPA is shown for the Nb membrane. Moreover, although Fe shows lower N_2 permeating flux with respect to V, it seems less brittle than V after having worked up to 600 °C and 60 bar. The results of this work suggest that V and Fe membranes can be used for N_2 separation leading to a near-pure stream of N_2, regardless of their low permeability; therefore, future work will be focused on the synthesis and analysis of V and Fe alloys in order to enhance the N_2 permeability and improve membrane resistance toward oxidation.