

## MODELLING THE EFFECT OF THE POROUS SUPPORT ON THE FLUX THROUGH ASYMMETRIC OXYGEN GAS SEPARATION MEMBRANES

Robert Mücke, IEK-1, Forschungszentrum Jülich  
 r.muecke@fz-juelich.de  
 Unoaku Unije, IEK-1, Forschungszentrum Jülich  
 Stefan Baumann, IEK-1, Forschungszentrum Jülich  
 Olivier Guillon, IEK-1, Forschungszentrum Jülich

Key Words: Gas separation membranes, binary friction model, microstructure, computed tomography.

Oxygen Transport Membranes (OTM) represent a new technology for energy-efficient oxygen generation which can be used in low-pollutant power plants and oxygen generators or membrane reactors in the chemical industry and health care. The two competing demands of low ionic resistance of the functional separation membrane and high mechanical stability lead to an asymmetric design comprising of a thin membrane layer and a thicker porous support. However, the overall membrane performance is strongly affected by the microstructure of this support layer which prevented the use of the full potential of such a design in the past. The effect of the support on the flux performance has been thus studied applying the Binary Friction Model (BFM, including binary and Knudsen diffusion and viscous flow) for the support together with a modified Wagner equation for the dense membrane. The transport-relevant parameters describing the tape-cast porous medium with an average pore diameter of 6.3  $\mu\text{m}$  were obtained by numerical diffusion and flow simulations based on micro computed tomography ( $\mu\text{CT}$ ) data (Fig. 1). The resulting fluxes were found to be in good agreement with the experimental permeation tests. Different flow conditions (3-end with vacuum, 4-end with Ar sweep gas), assembly orientation, feed atmospheres (air/ $\text{O}_2$ ) were modelled and the effect of geometrical changes in the support (pore size, pore anisotropy, layer thicknesses) on the overall flux studied. Knudsen diffusion was found to dominate the transport process for small pore sizes ( $\sim 2 \mu\text{m}$ ) in particular for the 3-end mode with the support on the permeate side being most pore size sensitive, whereas for the other configurations the viscous flow was of higher significance. For typical pressure conditions, the oxygen flux was found to be superior in the 3-end mode with the support on the permeate side as in this case the absence of a second gas in the substrate allows a fast transport of the permeate gas through the porous medium (Fig 2).

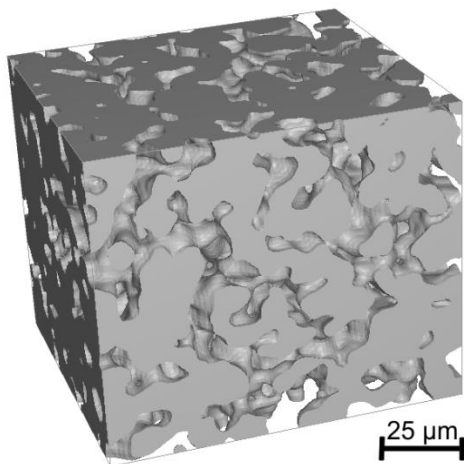


Figure 1 – Computed tomography ( $\mu\text{CT}$ ) of tape cast support (cropped)

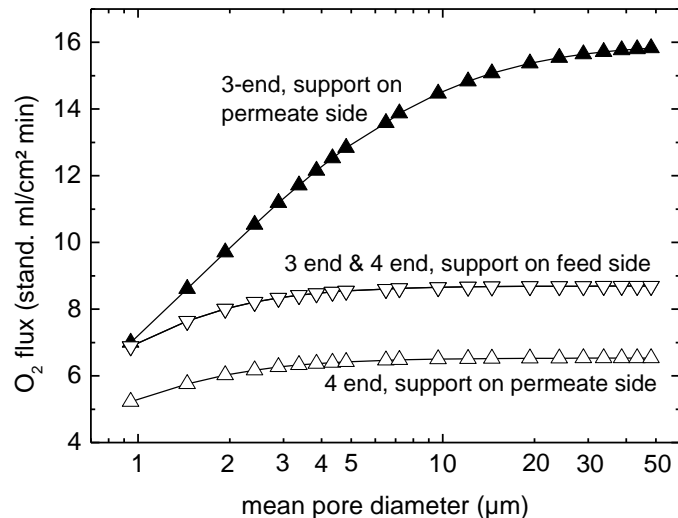


Figure 2 – Calculated  $\text{O}_2$  flux through an asymmetric  $\text{Ba}_{0.5}\text{Sr}_{0.5}\text{Co}_{0.8}\text{Fe}_{0.2}\text{O}_{3-\square}$  (BSCF) membrane at  $900^\circ\text{C}$  for varying pore diameters in the support and different operation modes. Feed side: air (1bar), perm. side:  $\text{O}_2$  ( $p_{\text{O}_2}=73.5 \text{ mbar}$ ) and Ar (4 end, 927 mbar)