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High Vacuum set-up for permeability and diffusivity measurements of vacuum materials

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Vacuum materials require precise knowledge of their permeability P and diffusivity D, e.g. for sealing or outgassing. Agreement with the methods to measure P and D, mainly infusion/outgassing or membrane techinques¹, is sometimes poor and material dependent².
The paper reports an experimental apparatus for gas flux measurements suitable for membrane techniques. It allows to measure transient fluxes and consequently simultaneously P and D³. A novel membrane assembly and the insertion of a Spinning Rotor Gauge (SRG) allow accurate results respect to a similar system described in ref. 4. A non-permeable material supports the permeation cell, composed by a freestanding membrane. Freestanding configuration avoids miscalculations of permeation area and unwanted lateral diffusion, artefacts often observed in membrane permeability measurements. A turbo pump maintains high vacuum conditions at the membrane downstream side. The system is equipped with a Residual Gas Analyzer (RGA), an Ion Gauge, a SRG, and a leak of known conductance. Upstream side of the membrane is equipped with diaphragm gauge. The measure of the stationary gas flow $\mathcal{J}$_{ss} generated by a known differential pressure of pure gas across the membrane allows to determine the permeability. The diffusion D is calculated by means of eq. (5) of ref. 4 integrating $\mathcal{J}(t)$ with respect to time. Because of fast response time of the RGA and taking into account that it is calibrated against SRG, the relative error on D is < 10%.

1 W. G. Perkins, Permeation and Outgassing of Vacuum Materials, Journal of Vacuum Science and Technology 10, 543 (1973)
2 Standard Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting. ASTM International Designation: D1434-82 (Reapproved 2015)
3 G. Firpo et al, Permeability thickness dependence of polydimethylsiloxane (PDMS) membranes, Journal of Membrane Science 481, 1–8 (2015)
4 P. Tremblay et al Gas permeability, diffusivity and solubility of nitrogen, helium, methane, carbon dioxide and formaldehyde in dense polymeric membranes using a new on-line permeation apparatus, Journal of Membrane Science 282, 245-256 (2006).

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