Development of a Gas and Vapor Transmission Rate Measurement Method using a Quadrupole Mass Spectrometer

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Introduction

Implantable devices require a high degree of biosafety which includes efficient protection against body fluids and maximal miniaturization. Today, implantable devices are encapsulated in conventional housing technologies made of glass or metal. While these casings are reliable, they have limitations in miniaturization potential and involve complex manufacturing processes. To address this issue, biocompatible thin film barriers have been developed with both organic and inorganic materials. Permeability being a key property for encapsulation applications, the aim of this work is to develop a characterization method able to quantify the permeability of these thin films.

Materials and Methods

The experiment is based on the design of the study of Yoshida et al. [1]. The tested films are made of parylene N, C, AF4 and VT4, in addition to multilayers stacks and silicon oxide. The permeants are two rare gases, helium and neon, and deuterium oxide. The purpose of D_2O is to avoid ambiguities of interpretation due to contamination by water in the measuring chamber. The aim is to be able to compare the permeation of these three molecules to the water vapor transmission rates (WVTR) already established in the literature. The measurements are made in ultra-high vacuum, using a quadrupole mass spectrometer to quantify gas or vapor molecules that diffuse through the films.

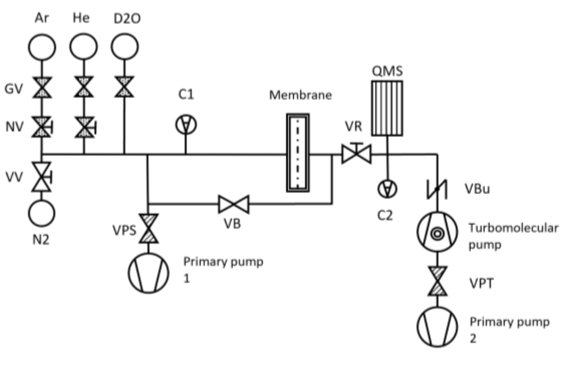

Figure 1: Scheme of the experimental diffusion setup

Results

The D_2O vapor transmission rate is lower than the WVTR for the same materials, however, still in the same order of magnitude. Similar results are obtained for the diffusion with helium. Concerning neon, a plausible transmission rate was only computable for the most permeable films.

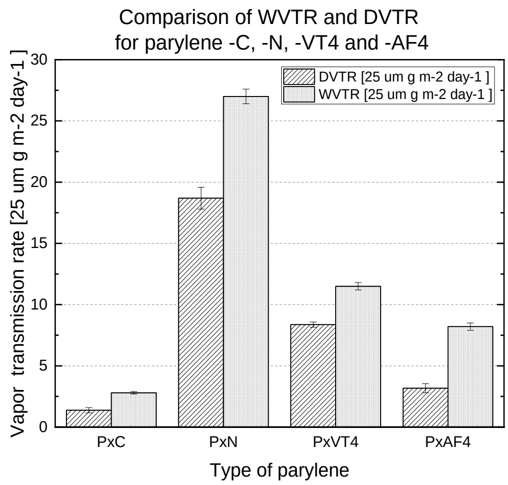

Figure 2: Comparison of WVTR and DVTR for four types of parylene

Discussion

The developed setup allowed to obtain very promising results with the diffusion through organic layers, whether with rare gases or D_2O. Indeed, the achieved results were aligned with those found in the literature [2]. However, the diffusion through ceramics and multilayers stacks needs more investigation. Finally, the comparison between water vapor and deuterium oxide vapor diffusion enabled to validate the setup for the permeability quantification.

References

[1] Yoshida et al., Development of water vapor transmission rate measuring device using a quadrupole mass spectrometer and standard gas barrier films down to the 10^{-6} g m^2 day^{-1} level, Review of Scientific Instruments, 88, 2017
[2] Buchwalder et al., Thermal Analysis of Parylene Thin Films for Barrier Layer Applications, Polymers, 14, 2022

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