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Transport properties of nanoporous 1,2-PB membranes with tunable hydrophilicity for use in biosensors

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Abstract – Nanoporous cross-linked 1,2-polybutadiene (1,2-PB) membranes derived from self-assembled block copolymers, in form of a flat sheet with gyroid morphology, was prepared for the development of diffusion-restricting outer membranes in biosensors. Glucose permeation measurements were performed for the nanoporous cross-linked 1,2-PB membranes with varying its hydrophilicity via UV treatment. Increasing the UV exposure time enhanced the extent of photo-oxidation of the membranes with the expected increase in water uptake. The membranes with long UV irradiation time show significantly larger glucose flux than the native membranes.

The development and characterization of well-defined, biocompatible, functionally-stable membranes is of particular interest for biosensor applications. In an assembly membrane system of a biosensor, an outer membrane is expected to implement some critical functions; of particular importance is elimination of interference and diffusion control [Ref 1-2].

In this work, permeation characteristics of nanoporous cross-linked 1,2-PB membranes derived from self-assembled block copolymers 1,2-PB-*b*-PDMS was initially investigated and evaluated as a promising candidate to be a diffusion-regulating outer membrane in planar biosensors. The 1,2-PB thin membrane in form of a flat disk with thickness of ~ 10 um (Figure 1, inset), was firstly solvent-casted by glass tube drawing the polymer solution on a Teflon-coated glass plate. TEM micrograph (Figure 1) shows the nature characteristic of gyroid structure in the membrane in wishbone view at [311] projection. Hydrophilicity of the native 1,2-PB membrane was adjusted by UV treatment (350 nm). Figure 2 shows the effect of UV irradiation time on the photo-oxidation of 1,2-PB membranes and the hydrophilicity derived. To illustrate the changing permeation characteristics, we started with glucose. Glucose permeation experiments were carried out with effective area of 0.13 cm^2 of the membrane separating the feed chamber (4 ml, 0.5 M glucose in isotonic saline solution with detergents) and permeate chamber (4 ml, isotonic saline solution with detergents). Commercial track-etched polyester membrane (PET) was taken as a reference membrane in the permeation experiments. As shown in Figure 3, the native membranes and those with less irradiation time show very low permeation to glucose. The high exposure time, e.g. 10 h and 12 h, leads to significantly improved glucose permeation, however, the resultant flux is much higher than the target value. From the present work, we found that 6-hour UV-treated membranes exhibit the similar permeation profile as the reference membrane PET. Optimization of the nanoporous 1,2-PB membrane is being performed. In general, the transport properties can be simply regulated by adjusting the hydrophilicity of the membranes with UV treatment.

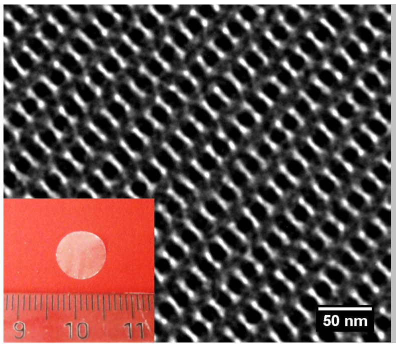

Figure 1: TEM micrograph of 1,2-PB nanoporous membrane displaying a wishbone view ([311] projection) of gyroid structure; inset: a disk of 1,2-PB nanoporous membrane (Ø9 mm).

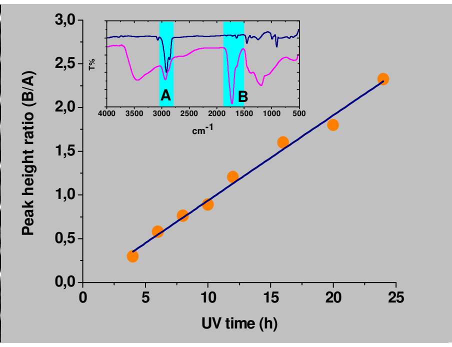

Figure 2: Height ratio of peak B and peak A as function of UV irradiation time; inset: FTIR spectra of the native 1,2-PB membrane and after 24 h UV exposure. Peak A: C-H at 2920 cm^{-1}; Peak B: C=O at 1717 cm^{-1}.

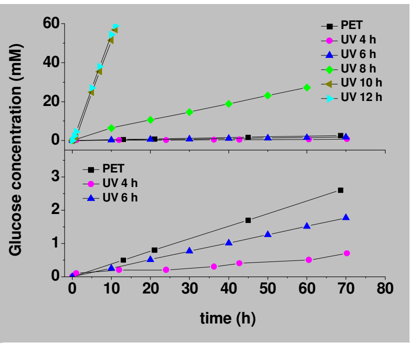

Figure 3: Dependence of glucose concentration on the permeate side versus time (top); Large view for the cases: UV 4h, UV 6 h and reference PET.

[1] U. Mathias, Polymer 47 (2006), 2217-2262.
[2] M. Andrew, A. David and V, Pankaj, Analytica Chimica Acta 333 (1996), 223-231.