DEVELOPMENT OF HEMODIALYSIS MEMBRANES FOR OUTSIDE-IN FILTRATION

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Introduction

Standard dialyzers used in hemodialysis (HD) therapy function by flowing the patients' blood through the lumen of each fiber, while the dialysate passes along the inter-fiber space. In this "inside-out" configuration, red blood cell accumulation at the device's entrance can occur, forming clots and effectively reducing the efficacy and longevity of the dialyzer. Changing the filtration mode—blood flowing in the space between fibers and dialysate flowing inside the fiber lumen—reduces the chance of blockages and potentially extends the duration of hemodialysis treatment [1]. For this "outside-in" filtration mode (OIF), the membrane morphology must also be adapted and reversed, so the selective biocompatible layer is on the outer fiber surface, in contact with the blood [2].

Methods

Outside-in hollow fibers were prepared by dry-wet spinning using polyethersulfone/polyvinylpyrrolidone polymer (PES/PVP) blends. The hollow fibers' physical (SEM, mechanical properties, and surface chemistry) and transport properties (molecular weight cutoff, toxin removal from human plasma spiked with creatinine, indoxyl sulphate and hippuric acid) were studied and compared with commercial HF membranes.

Results

Figure 1 presents typical SEM images of two membranes selected for their representative characteristics, of all the fabricated membranes. They both have a smooth selective layer on the outside and a highly porous layer on the inside.

While the ultrafiltration coefficient of the membranes is quite different (due to different polymer concentrations, table 1), both membranes remove similar amounts of creatinine (Cr), hippuric acid (HA) and indoxyl sulphate (IS) for human plasma, while losing < 10% of the total protein content, in outside-in mode.

Table 1: Properties of selected hollow fiber membranes.

	P10P4	P8P4
ID/OD/Wall (µm)	280/440/95	240/409/101
K_{UF} (mL/(m^2.hmmHg))	13 ± 1	28 ± 3
Cr removal (mg/m^2)	1307 ± 112	1412 ± 139
HA removal (mg/m^2)	1122 ± 203	1024 ± 214
IS removal (mg/m^2)	332 ± 55	266 ± 58

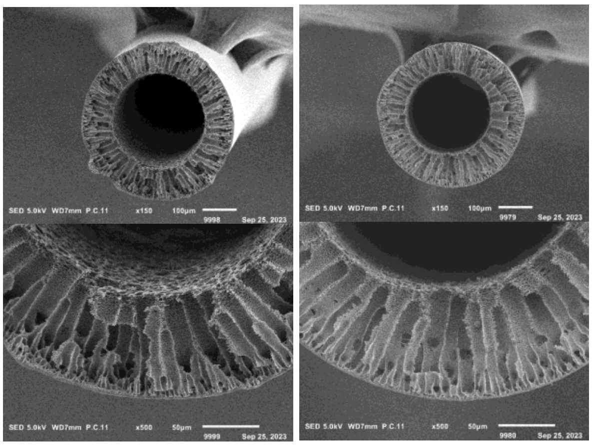

Figure 1: SEM images of the 2 fibers tested. Left image shows the fiber P10P4 (10% PES and 4% PVP) while the right image shows the fiber P8P4 (8% PES and 4% PVP).

Discussion

This study describes the development of membranes for OIF HD. With optimizations to the polymer composition (to improve mechanical properties) and dialyzer design (suitable for OIF), we expect to improve the performance even further of these membranes.

References

1. Dukhin, S., et al., Outside-in hemofiltration for prolonged operation without clogging, Journal of Membrane Science, 464 (2014), p. 173-178.
2. Ramada, D.L. *et al.* (2023) 'Portable, wearable and implantable artificial kidney systems: Needs, opportunities and challenges', *Nature Reviews Nephrology*, 19(8), pp. 481–490.

Acknowledgements.

We thank Mr. Marc Ankone for his help in the mechanical properties' experiments.

D. Ramada acknowledges the financial support of the Top Sector Life Sciences & Health (Health~Holland), NODIAL project 21OP+035).