Problem statement

Kidneys have the crucial task of purifying our blood. Patients with only 10% kidney function left will get slowly poisoned, because by-products such as creatinine and urea are no longer or not sufficiently filtered from the blood anymore. Kidney failure could be innate or it could be due to an injury or unhealthy lifestyle (smoking, unhealthy diet, etc.). Due to an aging population and the prevalence of these risk factors the incidence of kidney failure is expected to rise.

The best treatment for kidney failure patients is a kidney transplantation, however, there are not enough donor organs available. Therefore, millions of patients depend on hemodialysis therapy worldwide. Unfortunately, hemodialysis has some disadvantages – even though it is a lifesaving therapy. First of all, patients need to go to the hospital three times a week to receive a dialysis session of usually four hours and this really limits their freedom and quality of life. Moreover, it takes a lot of time to remove toxins from patients' blood. Longer treatment times are therefore suggested, for example in the form of nocturnal dialysis, portable and wearable dialysis systems. However, dialysis filters are not suited for these prolonged applications yet. Research has namely shown that dialysis filters lose hydrophilic additives during dialysis treatment. Another major disadvantage of current hemodialysis systems is that the dialysis filters are not able to remove all kinds of toxins. Especially, the middle molecules and protein-bound toxins are difficult to filter from the blood. Finally, the carbon footprint and biological and ecological effects of the therapy are hot topics as well nowadays. Research focusing on these issues include, for example, the search for 'greener solvents' to be used for the manufacturing of the filters' membranes and ways to regenerate the therapy's dialysate solution [1-5].

Hemodialysis filter

Ultimate goal

In order to improve hemodialysis, the following is needed:
A) a system that mimics the "healthy kidneys" and filters the blood for longer periods of time or continuously like in nocturnal dialysis or in a portable/wearable artificial kidney.
B) a system that can remove the middle molecules and protein-bound toxins.
C) a system that has a smaller carbon footprint.

Assignment goal

The goal of your assignment is to *prepare* and *characterize* hollow fiber membranes based on new polymers from the company BASF for hemodialysis filters [6,7]. The new fibers should be similar qua dimensions to commercial hollow fiber membranes and they should have excellent water permeance, toxin removal and fouling retention.

Research question: Is it possible to fabricate hollow fiber membranes from new BASF materials suitable for hemodialysis therapy?

Experiments & equipment

1. Spinning of polymeric hollow fiber membranes based on new BASF materials, suitable for hemodialysis, with dimensions similar to commercial dialysis membranes. Preparation of 'mini-modules' – small dialysis filters to be used for transport experiments.

2. Characterizing the hollow fiber membranes, using:
- Scanning Electron Microscopy (SEM), to study membrane structure and morphology
- Fourier-transform infrared spectroscopy (FTIR), to study membrane surface
- Clean water flux (CWF), to determine the water permeance of the fibers
- Dialysis experiments (4h diffusion experiments) and high performance liquid chromatography (HPLC) analysis, to study toxin removal
    → Creatinine removal
    → Indoxyl sulphate and hippuric acid removal
- Long-term experiments (24h)
- Retention experiments (bovine serum albumin)

References

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