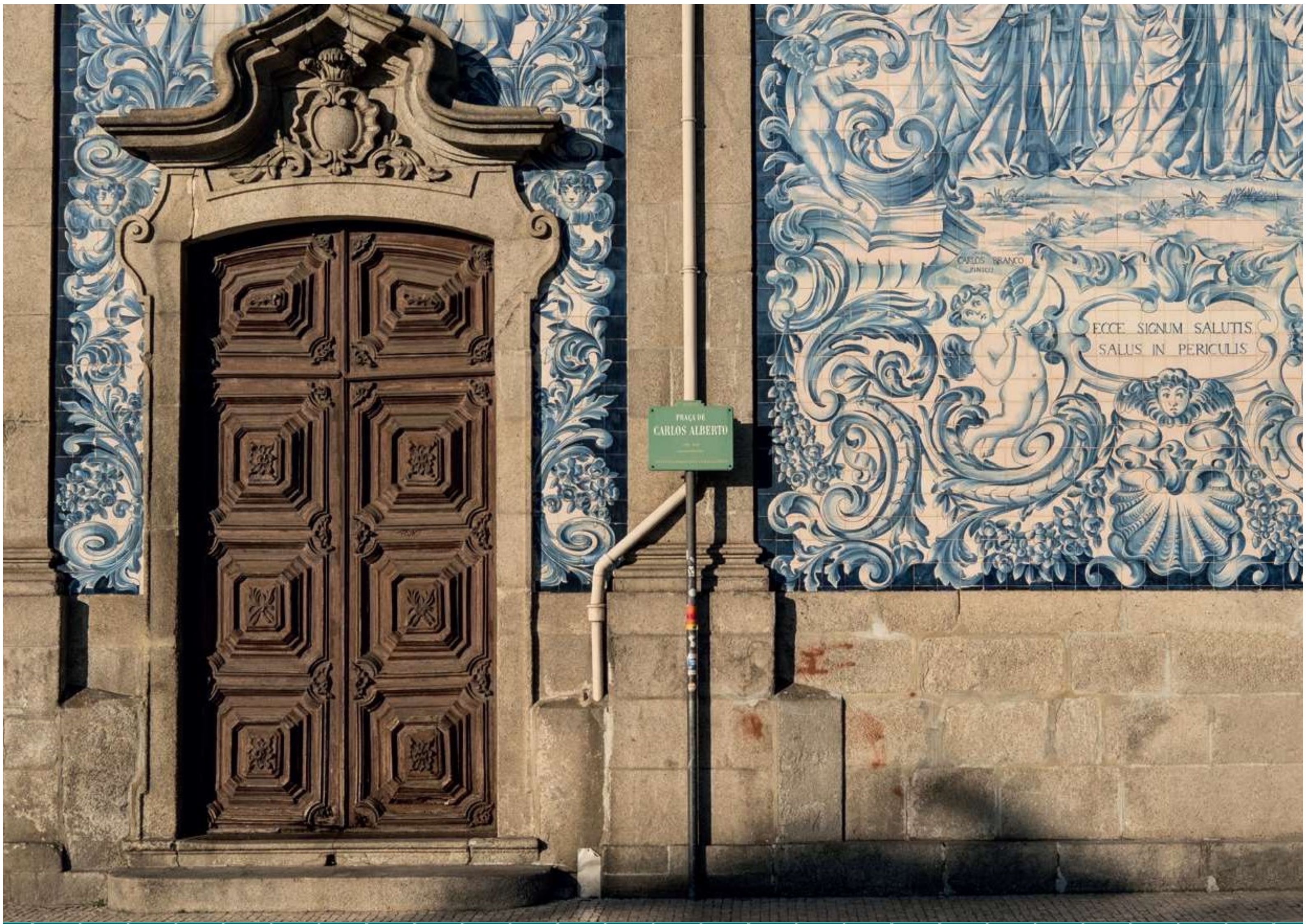

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ABSTRACT BOOK

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NATURE-INSPIRED MEMBRANES FOR ARTIFICIAL RESPIRATION – PRODUCTION OF MICRO-STRUCTURED POLYMER HOLLOW FIBERS

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Introduction

Modern respiratory support devices such as extracorporeal membrane oxygenators use state-of-the-art technology to provide the best possible support for the weakened human lungs of patients suffering from severe forms of respiratory disease. However, the survival rate after ECMO treatment is still low at 60-70 % [1]. Part of this mortality rate can be attributed to hemodynamic complications caused by the blood prime volume, which is a critical limiting factor for the design and size of oxygenators [2].

A promising approach to making such devices more efficient is demonstrated by nature using the example of fish. Micro-ridges in gills increase the respiratory surface area and lead to transverse flows, promoting oxygen diffusion, resulting in a decreased mass transfer resistance [3]. Recent CFD simulations utilize this biomimetic approach and show that micro-structuring hollow fiber membranes is a viable way to increase the volume to gas exchange area ratio but may also carry the risk of increased thrombus formation [4].

This work presents the production of micro-structured hollow fiber membranes via the non-solvent induced phase separation (NIPS) technique and evaluation of separation performance and flow characteristics.

Methods

Spinnerets with differently designed outlet openings were integrated into our self-developed hollow fiber membrane spinning plant at TU Wien. The plant's design allows for varying all crucial parameters of the NIPS manufacturing process, which ensures that the spun membrane's geometrical structure and consequently the gas separation properties can be influenced. Light and scanning electron microscopy provided a first impression of the geometrical properties of the hollow fiber membranes (Fig. 1).

To quantify the increase in separation performance of the micro-structured fiber, bundles of fibers are assembled into modules and compared with modules prepared from cylindrical fibers with respect to their gas permeance properties. The flow of the deoxygenated blood around the micro-structured shell side of the fiber in the module bundle is investigated using micro-particle measurement technology. For this purpose, an optically accessible, 3D printed flow channel with staggered fiber arrangement is used (Fig. 2), which reveals possible areas of increased thrombus formation.

Results

Fibers were fabricated at room temperature from a 16.6% PES, 4.9% PVP K30, 4.9% PVP K90, 7.2% H_2O polymer blend, dissolved in 66.4% NMP. Deionized water was used as internal bore fluid and external coagulation bath. A spinneret with four flanks arranged as a cross-slot shape served as the contouring structure of the hollow fiber membrane. Fig. 1 shows the most pronounced microstructure observed at 1.8 ml/min flow rate for dope and bore fluid and an air gap length of 5 mm. All flanks are uniformly shaped.

Figure 1: Micro-structured PES-PVP hollow fiber membrane spun with a self-developed spinning plant.

Figure 2: Staggered arrangement of 3D-printed micro-structured fibers in a flow channel.

Discussion

Preliminary spinning trials with micro-structured hollow fiber membranes show that geometry optimization of the outer surface is a promising approach to increase mass transfer in membranes and thus to increase the efficiency of blood oxygenators. Further spinning experiments and variations of parameter settings are required for the manufacturing process.

References

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