Biomimetic hollow fiber membranes for organ support

Gabriele Malagoli [a], Riccardo Onesti [a], Cristiana Boi [a,b,c]

[a] Department of Civil, Chemical, Environmental and Materials Engineering, University of Bologna, Italy
[b] Biomanufacturing Training and Education Center, North Carolina State University, Raleigh, NC, USA
[c] Department of Chemical and Biomolecular Engineering, North Carolina State University, Raleigh, NC, USA

E-mail: gabriele.malagoli5@unibo.it

Extracorporeal membrane oxygenation (ECMO) is a life-support technique used in the intensive care setting to provide respiratory support. Commercial ECMO devices typically use asymmetric polymethylpentene (PMP) hollow fibers, which suffer from low gas permeability and poor hemocompatibility, resulting in low survival rates. Our goal is to produce hollow fibers with a smaller inner diameter and wall thickness compared to commercial ECMO devices, to increase the surface area and the gas mass transfer. To this end, thermoplastic polyurethane (TPU) hollow fibers for ECMO devices were fabricated using immersion precipitation 3D printing (ip3Dp), an innovative technique combining phase inversion and additive manufacturing. In this method, a robotic arm equipped with a syringe extrudes the casting solution directly into the non-solvent bath following a CAD-defined path, allowing the creation of the desired membrane structure. To identify the parameters influencing fiber morphology, several filaments were printed using different nozzle sizes (from 14G to 32G), polymer concentrations (5 to 15% TPU in dimethylformamide), and dispensing speeds in the XY plane. Fiber analysis by scanning electron microscopy revealed that the internal and external morphologies were strongly influenced by the combined effect of nozzle size and polymer concentration. Operating at a high polymer concentration and large needle diameter (i.e. 15% w/w and 1.6 mm respectively) produces fibers with reduced internal porosity and a dense skin layer (Figure 1a). Reducing the needle diameter, for example to 0.5 mm, results in filaments with a hollow core surrounded by a layer of porous polymer with a dense skin layer (Figure 1b). These preliminary results open the way to the production of innovative structures made of very thin hollow or filled fibers with a tailored morphology such as the cylindrical structure shown in Figure 1c, with the perspective of mimicking efficient lung apparatus, such as that of birds.

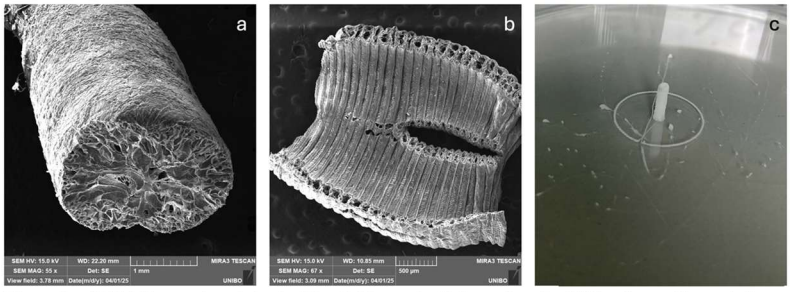

Figure 1. a) TPU filaments printed with a 14G nozzle (1.6 mm) and a 15% w/w casting solution; b) TPU filaments printed with a 24G nozzle (0.5 mm) and a 10% w/w casting solution; TPU cylindrical structure printed with a 30G nozzle (0.3 mm) and a 15% w/w casting solution.

Keywords: *3D printing, ECMO, Artificial lungs, Hollow fiber membranes*

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