SOLVING THE PROBLEM LAYER BY LAYER: DESIGNING SCAFFOLDS FOR CARDIOVASCULAR TISSUES

Birgit Glasmacher[1], Lutz Dreyer[1], Oleksandr Gryshkov[1], Alexander Kern[1], Rieke Kortlepel[1], Benjamin Krolitzki[1], Marc Müller[1], Alexandros Repanas[1], Holger Zernetsch[1], Dimosthenis Mavrilas[1,2]

[1]*Institute for Multiphase Processes, Leibniz Universitaet Hannover, Germany*

[2]*Laboratoy of Biomechanics & Biomedical Engineering, University of Patras, Greece*

Introduction

In Europe, almost 50 % of all mortality cases are related to cardiovascular diseases, with arteriosclerosis playing a major role [1]. A promising way to repair diseased vessels is to implant electrospun tubular scaffolds seeded with autologous cells. While mimicking the structure and the function of the native tissue, this method also avoids foreign body reactions induced by common synthetic grafts. Because of their intention to provide structural support for the cells, the mechanical properties of these scaffolds have to be in a physiological range. Furthermore, to achieve good seeding efficiency, the material used has to be highly biocompatible.

Methods

With our custom-made electrospinning setup, we fabricated multi-layered scaffolds (Fig. 2) with a specific inner and outer layer to improve cell compatibility and infiltration. These layers were spun out of a polymer blend consisting of polycaprolactone, polylactide and polethyleneglycol. The two layers were separated by a hydrophobic layer of poly-caprolactone, which was intended to minimise the leakage in highly porous grafts.

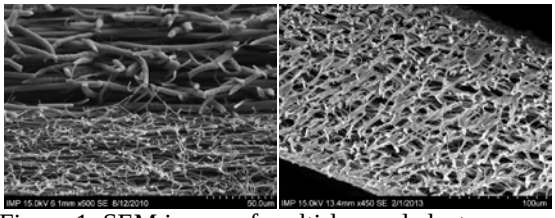

Figure 1: SEM image of multi-layered electrospun scaffold (600x, left) and of the wall thickness of a tubular scaffold (450x, right).

All scaffolds were spun on a rotating mandrel collector ($Ø_i$ 4 mm, 1000 rpm) by using an electric field strength of 66 kV/m and a spin duration of 3 min per layer. Fibre diameters and pore sizes for the inner and outer layers were examined by SEM. A dynamic tensile testing system (BOSE, Electroforce) was used to run cyclic sinusoidal mechanical tests (0 – 10 % strain, 1 Hz, dry conditions and room temperature) on ring samples ($Ø_i$ 4 mm, width 5 mm). Local strain and force were measured for 60 cycles and the recorded data was used to calculate stress/strain values, hysteresis and Young's modulus.

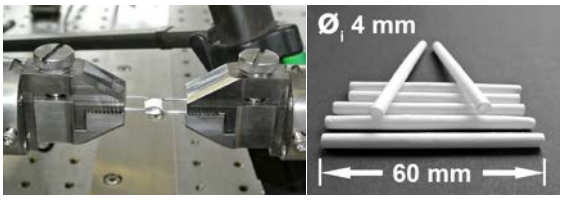

Figure 2: Dynamic tensile testing setup with mounted ring sample (left). Multi-layered electrospun tubular scaffolds (right).

Results

According to preliminary results, the multi-layered scaffolds had a wall thickness of 195 µm. Furthermore, no differences between inner and outer layers were observed for mean fibre diameter (2 µm, n=120) and the pore size (85 µm², n=50). Young's modulus, determined for the circumferential direction, showed a mean value of 15 MPa (n=5). Hysteresis, based on stress and strain values of the loading and unloading phase, was calculated to be 49 %.

Discussion

Regarding the preliminary results our electrospinning setup is suitable to fabricate standardised multi-layered tubular scaffold with desired mechanical properties. Further experiments with electrospun scaffolds (Peel Test, longitudinal testing) and comparative studies with native tissue should prove the potential of the multi-layered grafts. Moreover studies on *in vitro* degradation of the electrospun grafts are in planning.

References

[1] European Cardiovascular Disease Statistics 2012 edition, European Heart Network and European Society of Cardiology, September 2012