Porous polymer tubes for urethral tissue engineering

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1. Introduction
• Hypospadias -> the opening of the urethra is abnormally situated
• affecting one in 200 to 300 male children
• In the most severe cases the operations have a 50 % complication rate. [1]
• Tissue engineering: structures with and without cells
-> contractions and strictures
-> not enough veins and nerves [2-3]
The aim of this study is:
To prepare suitable replacements for urethra, which are:
1) porous
-> to enable the regeneration of veins and nerves inside and reduce the migration of the implant
2) biocompatible
-> to reduce the inflammatory reaction upon implantation

2. Materials and Methods
• Polylactide (PLA)
Medical grade poly(L/DL)lactide 70/30, Evonik Nutrition and Care GmbH
• Poly(butylene succinate) (PBS)
Bionolle 1020 MD, Showa Denko
• Carbon dioxide ≥ 99.8 % purity, AGA

1. PLA, PBS and PLA/PBS 75/25 and 50/50 blend rods were prepared with a twin-screw extruder.
2. The rods were processed into porous blocks and tubes (Fig. 1) with supercritical carbon dioxide (Table 1) in a high-pressure vessel Thar SFC (Waters, Milford, United States).

Table 1. Processing parameters of the supercritical carbon dioxide foaming.

<table>
<thead>
<tr>
<th>Form</th>
<th>Material</th>
<th>Saturation time (min)</th>
<th>Saturation pressure (bar)</th>
<th>Foaming temperature (°C)</th>
<th>Depressurising time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>PBS</td>
<td>60</td>
<td>300</td>
<td>115</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Blends</td>
<td>60</td>
<td>300</td>
<td>115</td>
<td>30</td>
</tr>
<tr>
<td>Tube</td>
<td>PLA, PBS, blends</td>
<td>60</td>
<td>300</td>
<td>115</td>
<td>20</td>
</tr>
</tbody>
</table>

3. Results and Discussion
Fig. 2. µ-CT images of the (A) 75/25 blend, (B) 50/50 blend, and (C) PBS porous blocks.
• All the block samples showed a homogenous porous structure with a relatively high porosity (average porosity 74.4 %, Fig. 2 and Table 2) and interconnective pores (Fig. 3 and 4).
• The tubes (D-G in Fig. 5) had a less homogenous porosity compared to the blocks, probably due to a different mould architecture.

Table 2. The total porosities and average pore sizes of the porous blocks.

<table>
<thead>
<tr>
<th>Material</th>
<th>Total porosity (%)</th>
<th>Average pore size (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLA/PBS 75/25</td>
<td>74.3</td>
<td>212 ± 55</td>
</tr>
<tr>
<td>PLA/PBS 50/50</td>
<td>68</td>
<td>304 ± 87</td>
</tr>
<tr>
<td>PBS</td>
<td>80.9</td>
<td>1117 ± 518</td>
</tr>
</tbody>
</table>

4. Conclusions and future plans
The average pore sizes of 200-300 µm and the interconnectivity up to 100 µm in the blend blocks make them promising for the ingrowth of blood vessels and nerves and suggest that these novel replacements could become viable alternatives for urethral tissue engineering. Next we plan to further optimize the processing conditions for the tubes to obtain a higher total porosity and more homogenous pores and also study their in vitro degradation and also cell response in collaboration with Susanna Miettinen and Reetta Sartoneva in the Adult Stem Cell Group within BioMediTech.

References