Limits to the utilization of polydopamine coating with the example of flax fibers as a substrate

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Statement of the Purpose: Implantable mesh structures are now used since 50 years to repair abdominal wall hernias [1]. Most of them are made from synthetic materials, but there is now a trend to look for biological materials (e.g. prepared from porcine skin), especially in complicated situations (e.g. infected area, open abdomen surgery) [2]. In another abstract, we explored the idea of designing woven meshes by using plant-derived fibers as flax fibers. Although the results obtained were promising, we observed that cells have little tendency to adhere to the flax. This may lead later to a risk of poor adhesion of the mesh with the muscle layer of the abdomen. The ability of dopamine to polymerize at pH = 8.5 has been first described by Lee [3]. Since then, numerous papers have shown that a polydopamine (PD) coating could help in improving adhesion, spreading and proliferation of cells on surfaces which usually resist to it [4]. Here, we checked if PD coating is also efficient toward cell adhesion and proliferation on flax fibers.

Materials and Methods: Starting with a bleached flax thread, a prototype mesh was industrially woven in a design similar to the Polypropylene Prolene TM (Ethicon, Livingston, UK). The mesh was treated with 5 % acetic acid for 24 hours and subsequently with 75% ethanol for a further 24 hours (double soxhlet treated). This treatment was aimed at improving biocompatibility. Then the mesh was coated with dopamine in 10 mM Tris (pH 8.5), and finally soxhlet washed with water for 24 hours to remove loosely attached PD. The amount of PD deposited on the mesh could be measured by using the Micro-BCA® protein assay reagent (Pierce,IL, USA) that also reacts with catecholamines. For assessment of in vitro biocompatibility, 3T3 cells were allowed to settle on or directly adjacent to the PD-coated meshes. Cell viability of adhered cells was studied using MTT and Live dead assay. The number of adhered cells after different times of incubation was determined with the Cyquant® cell proliferation assay (Bleiswijk, The Netherlands).

Results: The analysis of the PD coating on the flax meshes revealed that upon extensive washing with water, a substantial amount of the PD detached (fig 1). After 8 hours of polymerization and subsequent washing a stable PD layer of approximately 5 µg/mesh remained on the mesh. In addition, our studies showed that the same amount of PD remained on the flax surface when using 0.2 or 2 mg/ml dopamine solution. The additional soxhlet treatment was proven to be necessary to achieve in vitro biocompatibility. Yet, the cell adhesion and viability was shown to be highly similar on the PD-coated and control meshes (fig 2). The conditions under which the PD coating was performed did not influence cell adhesion and proliferation rates (fig.2). Similar results were obtained with HMEC-1 endothelial cells.

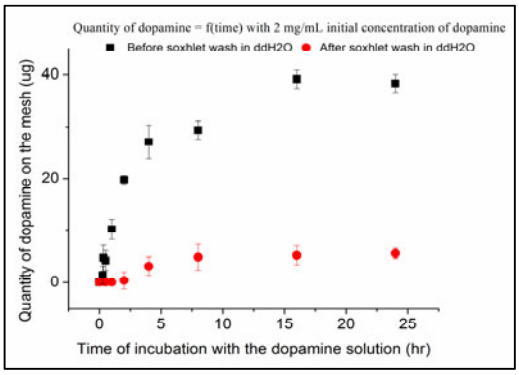

Fig. 1 : Amount of polydopamine coated on a 1*1cm mesh as a function of the time of incubation with the dopamine solution (Micro BCA® analysis).

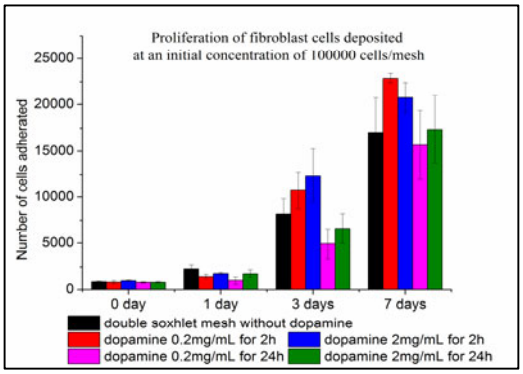

Fig. 2 : Cell adhesion and proliferation on uncoated and different PD coated 1*1cm meshes.

Conclusion: In this study we show that flax fibers are able to support the adhesion and growth of fibroblasts. The modification of the surface with poly-dopamine does not influence the behavior of cells. These results are in contrast with several studies that have shown enhanced cell growth on PD-coated surfaces. Yet, most of these studies were done on hydrophobic and non-fouling materials, and it is possible that these different results are due to hydrophilic nature of flax fibers. Finally, the low amount of PD deposited on these highly hydrophilic surfaces may also account for the absence of cell-compatibility improvement.

References:

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