A New Route to Produce Starch-based Fiber Mesh Scaffolds by Wet Spinning and the Improvement in Cell Attachment and Proliferation by Tailoring Their Surface Properties

K. Tuzlakoglu, I. Pashkuleva, M.T. Rodrigues, M. E. Gomes, R.L. Reis

[1] 3B's Research Group- Biomaterials, Biodegradables and Biomimetics, Univ. Minho, Campus de Gualtar, 4710-057 Braga, Portugal

[2] Department of Polymer Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal

Statement of Purpose: Fiber-based structures represent a wide range of morphological and geometric possibilities that can tailored for each specific tissue engineering application. Starch-based fiber meshes produced by melt spinning/fiber bonding have shown promising results for the use in the applications of the bone tissue [1].

In the present study, we described a new route for the production of starch-based fiber mesh scaffolds which would allow to form the scaffolds during the spinning. This new route would also provide to avoid the degradation of the polymer which is the main problem of melt-based systems.

Methods: Starch-based fiber mesh scaffolds were produced from starch/polycaprolactone (SPCL) (70/30) blend by wet spinning method. In order to obtain a polymer solution with a proper viscosity, SPCL was dissolved in chloroform at a concentration of 40% w/v. Methanol is used as a coagulant. A certain amount of polymer solution was subsequently extruded into a coagulation bath. The fiber mesh structure was formed during the processing by the random movement of the coagulation bath. The formed scaffolds were then dried at room temperature overnight.

In order to improve cell attachment and proliferation, the wet spun SPCL fiber mesh scaffolds were treated by plasma at 30 W for 15 min under Ar atmosphere.

A human osteoblast-like SAOS-2 cell line was selected for the direct contact assays. Cells were seeded onto the both untreated and treated scaffold using a density of $3x10^5$ cells/scaffolds and allowed to grow for two weeks. After 7 and 14 days of culture, cell/scaffold constructs were analyzed under a Scanning Electron Microscope (SEM). The DNA and ALP assay was also performed to detect cell proliferation and ALP activity at the same time intervals, respectively.

Results/Discussion: Figure 1 presents the μ-CT and SEM images of SPCL fiber mesh scaffolds produced by wet spinning. As it can be clearly seen, the SPCL fibers were randomly formed in the structure with a diameter of about 100μm.

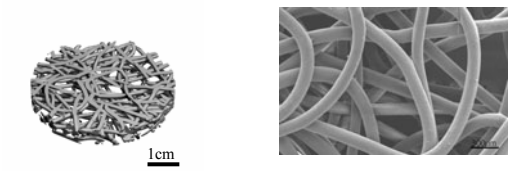

Figure 1. SPCL fiber mesh scaffolds produced by wet spinning.

Due to the phase inversion during the precipitation, the surface of the fiber showed non-smooth topography

(Figure 2). After plasma treatment, a significant difference on the fiber surfaces was observed (Figure 2b). It can be due to the etching during the plasma treatment. The influence of the plasma treatment was also confirmed by XPS, showing an increase of the oxygen content of the fiber surfaces (untreated scaffolds C/O:3.77 and plasma treated scaffolds C/O:3.15).

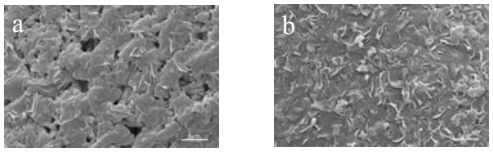

Figure 2. The surface of the SPCL fiber mesh scaffolds; a) before and b) after Ar plasma treatment (x3000).

Regarding cell culture studies, it was observed by SEM that there were no differences in cell shape and cytoskelatal organization of the cells seeded on both untreated and treated scaffolds (data not shown). Although the osteoblasts can not recognize the surface roughness less than 5μm [2], they showed a high response to the chemical changes on the surface. Therefore, there were significant differences on DNA amount and ALP activity between untreated and treated scaffolds after 7 and 14 days of culture (figure 4).

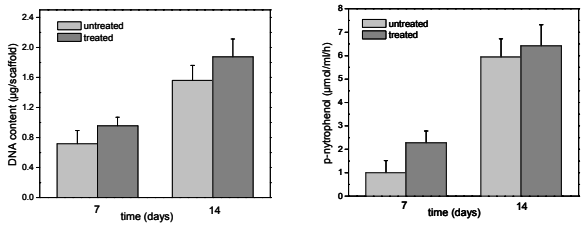

Figure 3. DNA and ALP assay for untreated and treated scaffolds.

Conclusions: A new route was described to produce starch-based fiber mesh scaffolds. The results from this study indicate that the wet-spun scaffolds can be formed during the process and have ability for osteoblast attachment and proliferation. It is also found that the cell proliferation can even be improved using plasma modification.

References:

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