University of Patras
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EFFECT OF SALINE ABSORPTION ON THE MECHANICAL BEHAVIOUR OF 3D-PRINTED PLA POROUS SCAFFOLDS

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INTRODUCTION

It is of paramount importance to find advanced materials so that the treatment of each disease can be painless and effective for the patient. Traditional biomaterials, such as metals and ceramics, are increasingly being replaced in medical applications by thermoplastic polymers.

In this study, we investigated the influence of simulated body fluid on the mechanical properties of 3D-printed PLA scaffolds and solid materials. Moreover, we examined their surface topography and we measured the biomarkers osteopontin, osteocalcin, alkaline phosphatase and total protein expressed in cells after incubation in the produced scaffolds for several days (3,7,15).

MATERIALS AND METHODS

For the experiments, scaffolds with two different pore sizes were constructed, 750 μm and 100 μm respectively, as well as compact PLA samples. The scaffolds as well as the solid materials were fabricated by 3D-printing.

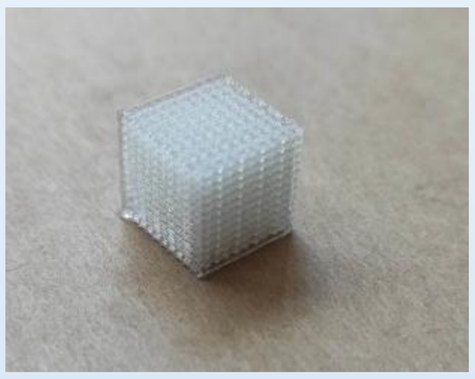

Figure 1: Scaffold made of PLA.

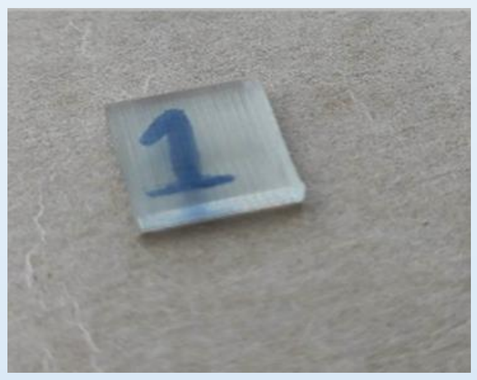

Figure 2: Compact sample made of PLA.

Figure 3: PLA scaffolds and compact samples in a glass container with the biological fluid.

A simulated body fluid normally used as a cell culture medium for *in vitro* experiments was prepared to assure the composition conditions prevailing in the human body. The scaffolds with pore size 750 μm and the compact samples were introduced together with the fluid in a glass container and placed on a magnetic stirrer. The experimental setup was maintained at 37˚C, as the temperature in the human body, while the magnetic created a continuous and smooth flow.

The experiment lasted 3 months. The first day of the immersion of the scaffolds and the compact samples in the biological fluid was considered as day 0. Then for days 1, 3, 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84 samples were removed to perform the experiments.

RESULTS AND DISCUSSION

Scanning electron microscopy (SEM) was used in order to obtain an accurate picture of the scaffolds morphology.

SEM images showed that fiber's color of the reference scaffold was uniform while its texture was smooth (Fig. 4). After 28 days of immersion, we can observe the breakage of long segments of the fibers (Fig. 5). From the moment this process begins, the failure of the scaffold's structure begins to accelerate, as it can be seen in the image in Figure 6. After 70 days of immersion, the scaffolds have almost completely dissolved.

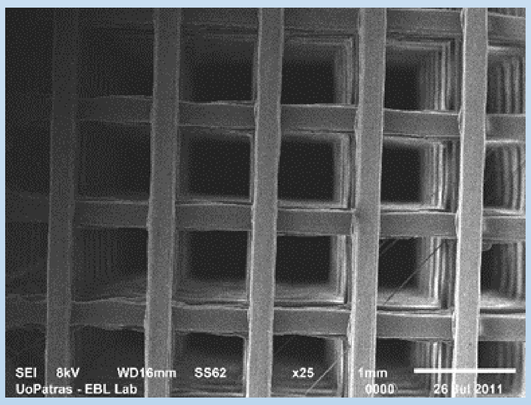

Figure 4: Reference scaffold.

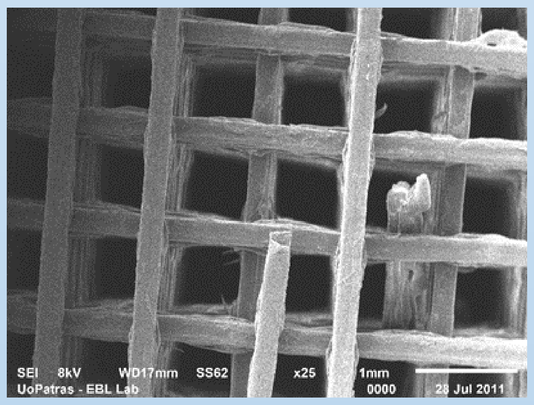

Figure 5: Scaffold day 28 of the immersion.

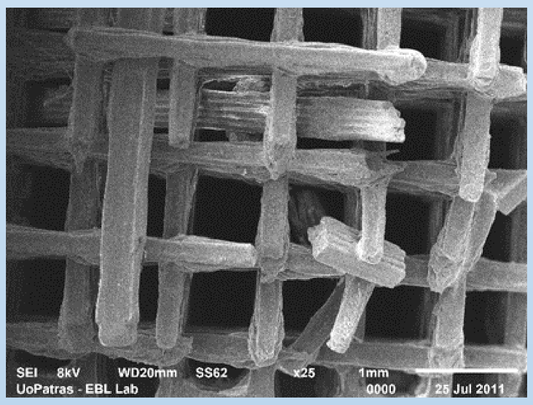

Figure 6: Scaffold day 56 of the immersion.

Both the 750 μm pore size PLA scaffolds and the compact PLA samples showed significant changes in terms of their physical and mechanical properties, depending on the time of their immersion in the biological fluid. In Figure 7 we can observe the percentage of mass change of the scaffolds as a function of their immersion time in the biological fluid. The weight of the samples slightly increases sometimes due to fluid absorption followed by adsorption in the fiber as exfoliation occurs, until 14 days of immersion. However, after 28 days of immersion the weight sample decreased constantly as the degradation becomes the dominating phenomenon.

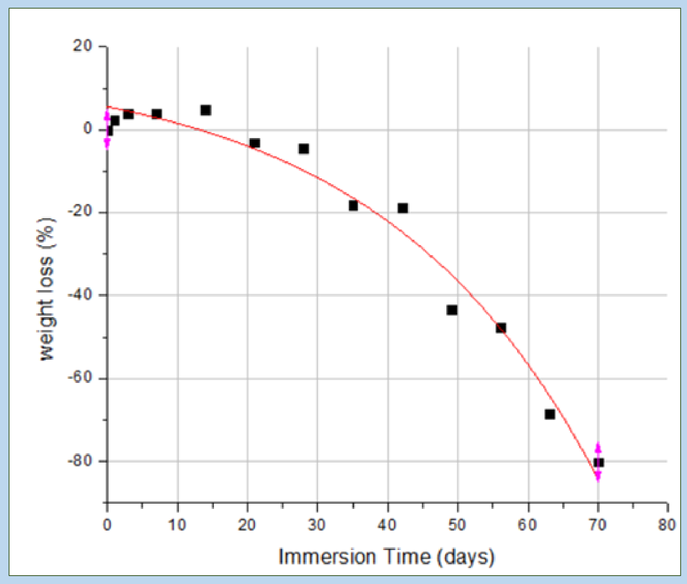

Figure 7: Variation % of scaffolds mass as a function of their immersion time in biological fluid.

In Figure 8 we can observe that the change of the compression modulus as a function of their immersion time in biological fluid follows an exponential decrease with the maximum rate of the change observed in the initial days of immersion while after 35 days of immersion the rate of the change tends to zero. The above variation is completely compatible with the microscopic observation.

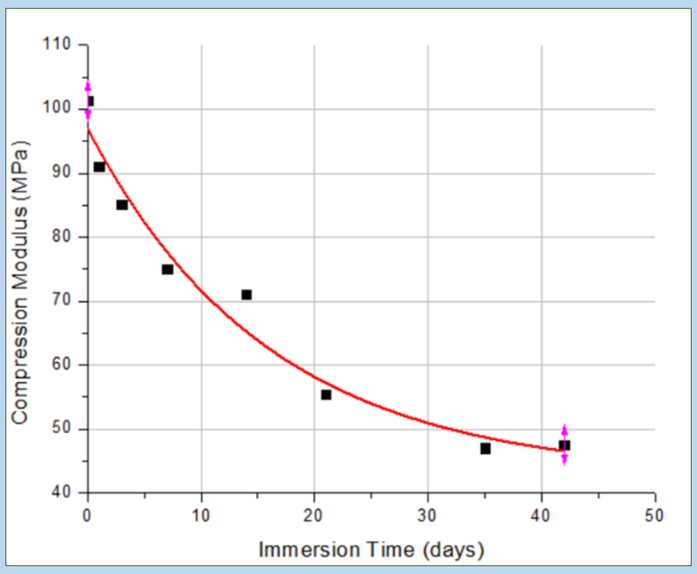

Figure 8: Compression modulus variation as a function of immersion time