Microhardness of Starch Based Biomaterials in Simulated Physiological Solutions as a Tool to Predict its Surface Stiffness When Implanted

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Statement of Purpose:

Starch-based biomaterials are biodegradable polymeric systems that have been proposed in our research group for several biomedical applications. The combination of biocompatibility, suitable mechanical and degradation properties constitutes one of the main advantages of these blends, for use on temporary biomedical applications. In this study the changes in the mechanical properties of some starch-based blends when they are immersed in a solution for different periods of time are evaluated by microhardness. Especially during swelling, the bulk mechanical properties of such materials will be different from those near the surface. Surface mechanical properties are important on determining cell responses, and microhardness can provide a possible way to measure the actual mechanical features of the surface layer, which is difficult to measure by traditional techniques. Parallel swelling and degradation tests were performed in order to study how the degradation of these starch biomaterials is affected by the hydrophobic or hydrophilic character of the other component and how this affects the respective mechanical properties.

Materials and Methods:

Two starch-based biomaterials were studied: a blend of corn starch (50/50 wt %) and cellulose acetate, SCA, and a blend of corn starch (30/70 wt %) and polycaprolactone, SPCL. All the materials were processed into disk samples (ϕ=1cm), by injection moulding. Samples of both materials were immersed in a phosphate buffer solution (PBS) and kept at 37.5ºC (pH=7.4), for distinct times (1minute to 30 days) in order to roughly simulate the degradation conditions in the human body, when the materials are implanted. Microhardness measurements were performed with a Leica VMTH30 equipment, using a Vickers pyramid indenter, (included angle, α=136º). Complementary characterization of the mechanical properties was accomplished by creep and dynamic mechanical analysis (DMA7 from Perkin Elmer).

Results and Discussion:

For SPCL it was found that microhardness decreased until the half of the initial value for immersion periods lower than 7 days (Fig. 1a). For SCA the microhardness value decreased more than for SPCL for the same immersion periods (Fig. 1b). This can be explained because the water uptake ability of the SCA is higher than the one for SPCL. SCA and SPCL dried samples were also measured and compared to the values obtained for the immersed samples. The observed differences in the water uptake ability of the materials are mainly due to the synthetic component present in the blends. In fact cellulose acetate is more hydrophilic. The hydrophobic nature of PCL will reduce the content and rate of water uptake in the corresponding blend, that will be reflected in the mechanical properties.

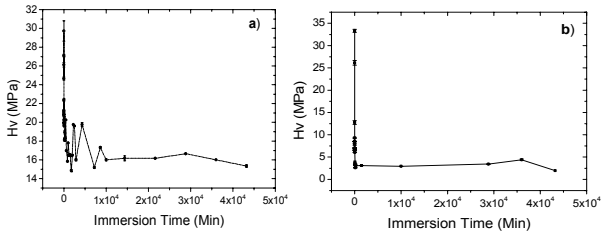

Figure 1- Microhardness of immersed samples of a) SPCL and b) SCA.

Regarding the degradation behaviour it was found that the major weight loss occurs in the first few days for both materials and that the weight loss of SCA is faster than SPCL (Fig. 2). The decrease of the mechanical properties when the materials are immersed, namely the observed variations in microhardness, were related to the degradation behaviour of each material.

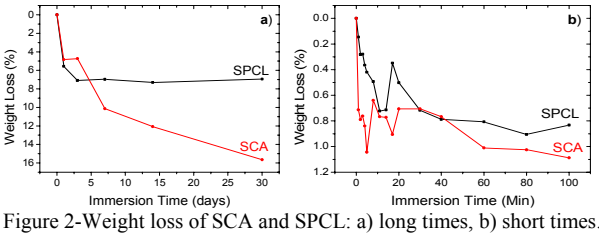

Figure 2-Weight loss of SCA and SPCL: a) long times, b) short times.

Conclusions:

The main change in the mechanical properties at the surface of starch-bases biomaterials upon immersion in simulated physiological conditions occurs at time scales of few minutes, being highly mediated by swelling. However, degradation may also have a role in such evolution. The blend with SCA exhibited a decrease in the microhardness more pronounced than for the blend with PCL for the same immersion periods. This can be due to the fact that SCA is more hydrophilic and presents more water uptake ability than SPCL. Microhardness is thus an adequate method to monitor the mechanical properties at the surface of biomaterials in order to predict the mechanical performance of an implant in contact with the tissue.

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