Enzymatic degradation of starch based blends thermoplastic compounds using different thickness samples

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Introduction

Starch-based polymers present an enormous potential to be widely used in the biomedical field, as they are totally biodegradable and inexpensive. These natural polymers can be found over a wide range of applications from scaffolds for tissue engineering, bone fixation or replacement (filling bone defects) or even working as carriers for the controlled release of drugs. Polymer degradation has major importance in the production, and use of implants. An ideal material to be used in temporary bone replacement should mechanical properties (matching those of bone), with adequate degradation kinetics, and biocompatibility [1]. Blends of starch with ethylene vinyl alcohol copolymer (SEVA-C) when immersed in simulated physiological solution exhibit adequate degradation behaviour [2].

Materials and Methods

The material studied was a thermoplastic blend of corn starch with a poly(ethylene-vinyl alcohol) copolymer (60/40 mol/mol), SEVA-C. Three different batches were tested using SEVA-C samples of different thickness (0.15 and 0.5 mm) in a Hank´s balanced salt solution (HBSS) with α-amylase, at pH 7.4 and 37ºC ± 1 ºC, up to 90 days. Films of SEVA-C were used for two batches, which correspond to 10 and 20 times (2 and 4 films) the surface area of the other batch (square plates of 30x30x2mm), using the same weight of 1.6 g. The reducing sugars in the degradation solutions were quantified by the dinitrosalicylic acid method (DNS). The changes on the surface morphology of SEVA-C, as function of immersion time, were followed by SEM using a Leica Cambridge S360 microscope. The plates were dried at 80ºC and the surface was cleaned and stored in a desiccators before analysis.

Results and Discussion

In order to study SEVA-C structural material limitation to α-amylase degradation, 3 batches of different thickness were applied using the same weight. Figure 1 evidences the increased reducing sugars released per specimen mass, as a function of immersion time. The amount of reducing sugars in the degradation solutions, increased during the assay for all the batches. The amount of glucose released is higher for film samples with greater surface than for square plates. Although, the difference between the amount of glucose released for 2 and 4 films is not relevant, one possible explanation could be that enzyme has already saturated in all the binding sites. This work demonstrates that the surface structure was the limiting factor for enzyme binding.

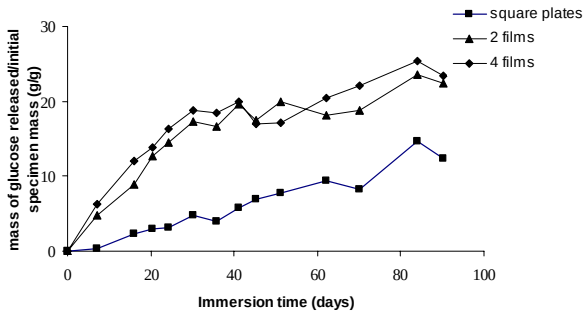

Figure 1 – Mass of glucose released to the solution for each batch, square plates, 2 and 4 films, per initial specimen mass in 50 ml of solution, as a function of immersion time.

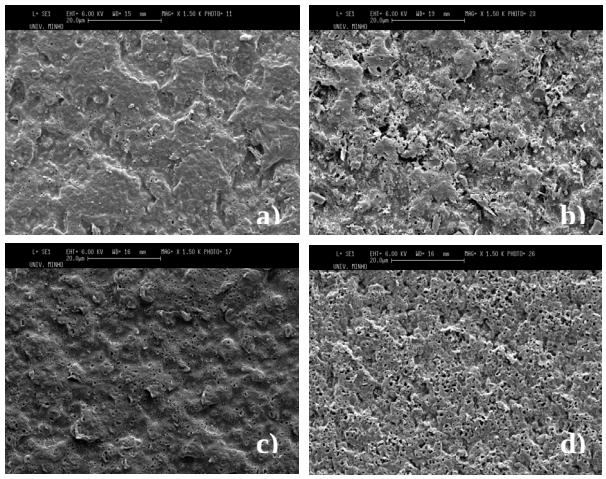

Figure 2. SEM micrographs of SEVA-C surfaces (x 1500): (a) and (c) control and (b) and (d) after 70 immersion days, for 2 and 4 films, respectively. The images present dried samples after immersion period.

The increase in the surface porosity and roughness as a function of immersion time can be clearly seen (Figure 2) by SEM. The control sample has a smooth surface compared to the very rough surface of the degraded samples, that evidences structural voids, after 70 days of immersion. Small protrusions were observed at the surface of the blends. This phenomenon should be related to the hydrolytic surface dissolution of the original sample. The enzyme attacks the surface structure of the material, leading to the progressive destruction.

References

1. J.F. Mano, Rui Sousa, Luciano Boesel, Nuno Neves, Rui L.Reis, Composites Science and Technology 2004; 64: 789-817.
2. M. Alberta Araújo, AM. Cunha, M Mota, J. Biomater. Sci. Polymer Edn 2004, Vol. 15; 10: 1263-1280.