BIOÉvora

DETERMINATION OF DIFFUSION COEFFICIENTS Of GLYCEROL AND GLUCOSE FROM STARCH BASED THERMOPLASTIC COMPOUNDS ON SIMULATED PHYSIOLOGICAL SOLUTION

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Introduction

Blends of native corn starch with poly(ethylene-vinyl alcohol) copolymer (SEVA-C), are potential alternatives to the biodegradable polymers used in clinical applications due to their degradation behaviour and properties [1]. It has been shown with starch-based scaffolds that porosity has a great influence on the delivering of the model, being possible to control the release profile with this material property. The release was controlled in the first stage by diffusion and in the second stage by the matrix degradation.

The objective of this work is to determine the effective diffusivities of two important components (glycerol and glucose) in SEVA-C samples of different thickness.

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, supplied by Novamont (Novara, Italy). Injection moulded square plates 30 mm wide and 2 mm thick were used for the assays.

Four different randomly selected batches were tested using 1, 10, 15 and 20 SEVA-C samples in different containers, considered as batches 1, 2, 3 and 4, respectively. The SEVA-C samples, were immersed 30 days at pH 7.4 and 37ºC±1ºC in individual containers (volume approximately 50 cm³), under continuous shaking (150 r.p.m.), with a Hank's balanced salt solution (HBSS).The values of the diffusion coefficient (D) for glucose and glycerol in the degradation solution, were determined based on the analytical solution for Fick's law of diffusion that neglects external mass transfer resistance, and solved by the use of Laplace transform [2]. Assuming plane sheet geometry, the analytical solution for for Fick's diffusion equation can be described by:

$$\frac{C'_t}{C'_\infty} = 1 - \sum_{n=1}^{\infty} \frac{2\alpha(1+\alpha)}{1+\alpha+\alpha^2 . q_n^2} \exp\left(\frac{-Dq_n^2 t}{l^2}\right)$$

The D parameter can be obtained applying a suitable least square procedure. The function "nonlinfit" from Statistic Toolbox of Matlab 6.5 (The Mathworks, USA) was used for finding parameter estimates in nonlinear modelling. The coefficient of determination, R^2, was also evaluated to account for the proportion of variation in the dependent variable that has been accounted for by the regression curve.

Results - Table 1 summarises the results obtained for D, including the 95% asymptotic confidence intervals and coefficient of determination, R^2, to account for the proportion of variation in the dependent variable.

***Table 1** - Calculated values of Diffusion coefficients of glycerol and glucose, the 95 % asymptotic confidence intervals (95% C.I.) and the coefficient of determination, R^2, for four batches performed, from the non-linear fit of experimental data using analytical approach.*

Batches	D_e(gly)x10^{10} (m^2/s)	95% C.I. x10^{11}	R^2	D_e(glu)x10^{11} (m^2/s)	95% C.I. x10^{10}	R^2
1	0.0659	± 0.785	0.889	1.62	± 1.455	0.872
2	2.10	± 9.655	0.962	3.07	± 0.171	0.684
3	2.89	± 12.54	0.950	9.09	± 0.254	0.930
4	8.08	± 21.68	0.992	25.07	± 0.737	0.967

Discussion: The changes in the diffusion coefficient along the batches depend directly on the material thickness. D tends to increase from batches 1 to 4 for glycerol and glucose. The model is more accurate for batches 3 and 4, as demonstrated by R values (R ≈1). The good agreement achieved confirms the validity of this model for the system.

The controlled pathway that is responsible for the non-diffusion is the diffusion step associated to the low porosity (approx. 0.05). The starch diffusion from the inner regions of the blend to the bulk zone is dependent on the low porosity of the material and the rearrangement inside the blend. The compounds leached to the solution is essentially glycerol, that present greater diffusion coefficient.

References: 1- M. Alberta Araújo, Cláudia M. Vaz, António M. Cunha, M. Mota, *Pol. Degr. Stab.* **73** (2001) 237-244 /**2.** Crank, J, in "The mathematics of Diffusion". 2nd edition.Oxford. (Clarendon Press, 1975).