A Novel Model for Diffusion Based Release Kinetics Using an Inverse Numerical Method

H. Mohammadi[1], W. Herzog[2]

[1]School of Engineering, Faculty of Applied Science, University of British Columbia (Okanagan Campus), Kelowna, British Columbia, Canada [2]The Human Performance Laboratory, Faculty of Kinesiology, University of Calgary, Alberta, Canada.

Introduction

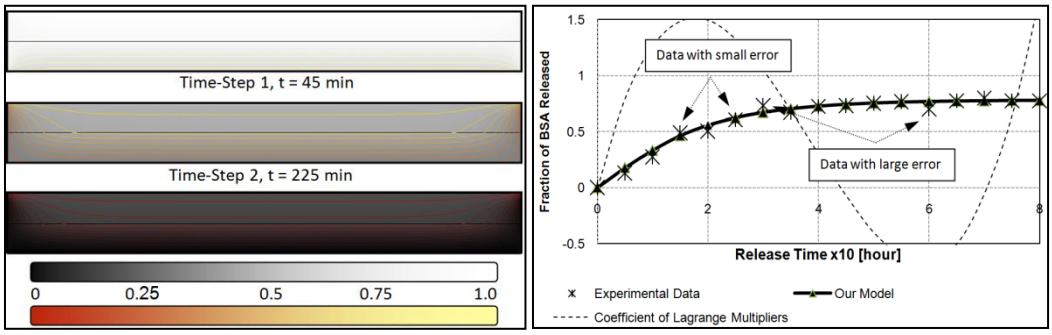
A novel inverse numerical model for the analysis of diffusion-based drug release from a polymeric matrix under dynamic conditions is developed. The proposed model is valid for the entire release process. Among all drug release models developed, the model by Baker et al. [1] is the most frequently used. Their model describes a diffusion-based release kinetic system using two sub-models: one for the short-term, and one for the long- term release. The model proposed here is used for calculating the coefficient of diffusion. Also, our model can model diffusion-based release kinetics for static- and dynamic- conditions with a precision equal to that obtained with the finite element method, but results are obtained in a fraction of CPU time.

Method

Given that the initial and boundary conditions are available, and that the data follow Fick's second law, Lagrange multiplier method and least-square algorithms are applied to define a residual function which is then temporally and spatially discretized using a finite difference method. This residual function is then optimized so that experimental errors are minimized and is then solved for the diffusion coefficient using appropriate means for nonlinear systems, such as Newton-Raphson method.

Results

Our model was used to describe the release of bovine serum albumin (BSA) from a polyvinyl alcohol matrix. This represents a conventional drug delivery device that is made using a thermal cycling process as cycle 1-PVA and cycle-6 PVA (referring to 1 and 6 freeze/thaw cycles).



Dynamic of release of BSA from a bi-layer PVA (cycle 1 and 6) obtained from our model (gray-bar) and a validated FE model (color-bar) [2] (right) – fraction of BSA released, and experimental and modeling data of the BSA release from the cycle 6-PVA (left).

Conclusion

The numerical method developed in this study can be widely used for drug release design, analysis, and optimization. It can also be used for tissue engineering/repair applications in which oxygenation of cells residing within the scaffold/tissue is of importance.

Reference

[1] Baker et al. *(1974), New York: Plenum Press; 15-72*, [2] Mohammadi *et al. (2010), Proc Inst Mech Eng H. 224(8):1005-1117.*