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NUMERICAL MODELLING OF PEROXIDASE-BASED OPTICAL BIOSENSOR

EVELINA GAIDAMAUSKAITĖ[1], ROMAS BARONAS[1,2]

[1] *Faculty of Mathematics and Informatics, Vilnius University*

Naugarduko 24, LT-03225, Vilnius, Lithuania

[2] *Institute of Mathematics and Informatics*

Akademijos 4, LT-08663, Vilnius, Lithuania

E-mail: `evelina.gaidamauskaite@mif.vu.lt, romas.baronas@mif.vu.lt`

Biosensors are sensing devices made up of a combination of a biological entity, usually an enzyme, that recognizes a specific analyte and the transducer that translates the biorecognition event into an electrical signal [1]. Optical biosensors are based on the measurement of absorbed or emitted light resulting from a biochemical reaction. A mathematical model of a peroxidase-based optical biosensor has been recently developed [2].

In order to define the main governing parameters, the corresponding dimensionless mathematical model of the peroxidase-based optical biosensor has been derived. The modelling biosensor comprises two compartments, an enzyme layer and an outer diffusion layer. The governing equations for the enzyme layer in a dimensionless form are defined as follows:

$$\begin{aligned}&\frac{\partial S}{\partial T} = \frac{\partial^2 S}{\partial X^2} - \alpha_2 CS, \quad \frac{\partial P}{\partial T} = \frac{D_P}{D_S}\frac{\partial^2 P}{\partial X^2} + \alpha_2 CS, \quad \frac{\partial H}{\partial T} = \frac{D_H}{D_S}\frac{\partial^2 H}{\partial X^2} - \alpha_1 EH,\\ &\frac{\partial E}{\partial T} = -\alpha_1 EH + \alpha_2 CS, \quad \frac{\partial C}{\partial T} = \alpha_1 EH - \alpha_2 CS, \quad 0 < X < 1,\ T > 0,\end{aligned} \tag{1}$$

where S, P, H, E, C are the substrate, product, hydrogen peroxide, enzyme and compound I dimensionless concentrations in the enzyme layer, D_S, D_P, D_H are the diffusion coefficients, X and T stand for dimensionless space and time. The dimensionless parameters α_1 and α_2 are known as the diffusion modules or Damköhler numbers [3].

The influence of the dimensionless diffusion modules on the biosensor response and the sensitivity was investigated. A quasi-steady state model for the peroxidase-based optical biosensor was also developed and investigated for the ability to accurately predict the biosensor response. The digital simulation was carried out using the finite difference method.

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