COMPUTATIONAL MODELLING OF BIOSENSOR-BASED ANALYTICAL SYSTEMS

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Biosensors are sensing devices made up of a combination of a specific biological entity, usually an enzyme, that recognizes a specific target analyte and a transducer that translates the bio-recognition event into an electrical signal \cite{1}. The signal is usually proportional to the concentration of the analyte (substrate). The biosensors are reliable, cheap and sensitive for environmental, clinical and industrial applications. Practical biosensors form sandwich-like structures. An electrode acting as a transducer is covered by a selective membrane following a layer of the immobilized enzyme and an outer porous or perforated membrane.

To improve the efficiency of the design of an analytical system and to optimize its configuration, a model of a certain biosensor should be build. In the enzyme region, the enzyme-catalysed reaction is coupled with the mass transport by diffusion and is described by a system of non-linear reaction-diffusion equations \cite{2; 3}. Assuming the quasi steady state approximation the dynamics of the biosensor action can be described as follows:

\begin{equation}
\frac{\partial S}{\partial t} = D_S \Delta S - \frac{V_{\text{max}} S}{K_M + S}, \quad \frac{\partial P}{\partial t} = D_P \Delta P + \frac{V_{\text{max}} S}{K_M + S},
\end{equation}

where \(\Delta\) is the Laplacian, \(S\) is the substrate concentration, \(P\) is the concentration of the reaction product, \(V_{\text{max}}\) is the maximal enzymatic rate, \(K_M\) is the Michaelis constant. Outside the enzyme region only the mass transport by diffusion is considered. The porous membrane was assumed as a periodic media, and a homogenization process was applied. The governing equations together with appropriate initial, boundary and matching conditions form a boundary-value problem, which was solved numerically by applying the finite difference technique.

The biosensor geometry and the catalytic parameters significantly influence the sensitivity and stability of the biosensors \cite{1}. The numerical simulation was applied to investigate peculiarities of the biosensor response and to optimize the biosensors characteristics \cite{2; 3}.

REFERENCES

