

Evaluation of Performance for Enzymatic Biofuel Cells with Microelectrode Arrays Inside a Blood Artery Via Finite Element Approach

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Abstract

Introduction

Enzymatic biofuel cells (EBFCs) are considered as a candidate for miniature implantable power sources, which use enzymes as catalysts to perform redox reaction with biological fuels such as glucose. In this study, the performance of an EBFC chip inside a blood artery, involving highly dense and three dimensional cylindrical microelectrode arrays has been simulated via finite element approach. Based on our previous results on microelectrode arrays' design rule and orientation of chip in the blood artery, the main focus of this research is to investigate diffusion of glucose, output potential, current density and power density of the EBFC chip under the transient state condition.

Use of COMSOL Multiphysics®

In the model design, we applied the 1) Michaelis Menten equation; 2) Nernst potential equation; 3) Navier Stokes velocity and 4) Fick's diffusion law to investigate the EBFC chip in the blood artery. Figure 1 is the geometry of one pair of anode and cathode immobilized with glucose oxidase (GOx) and laccase, respectively.

There are three models applied in this design:

1. Conductive media DC application model

Boundary Condition

Enzyme layer interface layer Insulation

Enzyme layers - bulk interface Continuity

Top boundary of outer bulk domain Inward flux

Bottom boundary of outer bulk domain Convective flux

SiO₂ boundary Insulation

2. Electro-kinetic application model

Boundary Condition

Enzyme layer interface Continuity

Enzyme layers - bulk interface Nernst potential expressions

Outer bulk Insulation/Symmetry

SiO₂ layer Insulation

3. Incompressible Navier-Stokes application model

Boundary Condition

Enzyme layer interface Wall - no slip

Enzyme layers - bulk interface Continuity

Top boundary of outer bulk domain Inlet pressure

Bottom boundary of outer bulk domain Outlet - No viscous stress

SiO₂ layer Insulation

Figures used in the abstract

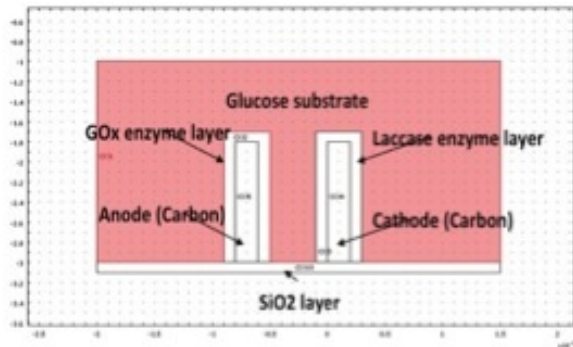


Figure 1: Schematic of EBFC.