Electrical Characterization of Biological Cells on Porous Substrate Using COMSOL Multiphysics®

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Abstract

In this paper, the gross electrical characterization of biological cells on porous substrate is analyzed using COMSOL Multiphysics®. The dynamic analysis during cell growth is required to understand the growth kinetics of cells. During the growth process, the cells are first attached with a protein-coated substrate, then will be grown and proliferated by increasing the cell numbers under proper culture conditions (370 C temperature and 5% CO2). The electric cell substrate impedance sensing (ECIS) platform first reported by Giaever and Keese [1] is used to study various cell biological processes like cell attachment, spreading, cell growth, and cell apoptosis [2-5]. But the different stages of growth cannot be distinguished. Extensive models have to be used to extract the cell parameters at different stages. So far, different flat substrates are used for cell culture. In this paper, we report the gross electrical characterization of biological cells on porous substrate. COMSOL is used to produce a model and study the total current density variations with different cell numbers for rectangular as well as circular electrodes on flat and porous substrate. The software provides an integrated geometry and graphical user interface for preparing the model, a computational solver for performing the simulation, and an interactive visualization program. In this study, the simulations are performed using the three-dimensional COMSOL AC/DC Module.The 3D model has been constructed in the drawing mode. The top view of cells on top of the pores with rectangular electrode is shown in Figure 1. The size of each cubic pore is 2×2×2 µm. The radius and height of each cylindrical cell is 2 µm. During simulation, the boundary conditions are set as an electric potential of 0.1 V on one electrode and ground on another electrode. In the subdomain settings, conductivity is given as the input variable. The conductivity of solution and cell are set as 10 S/m and 0.01 S/m respectively.Three distinct simulations have been performed: (i) cells on flat substrate, (ii) cells on top of the pores and (iii) cells outside the pores. The percentage changes in the total current density with the number of cells for rectangular electrodes and circular electrodes are shown in Figure 2 and Figure 3, respectively. It is observed from these two figures that the percentage change in the current density is greater in porous substrate than in flat substrate.

Reference

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Figures used in the abstract

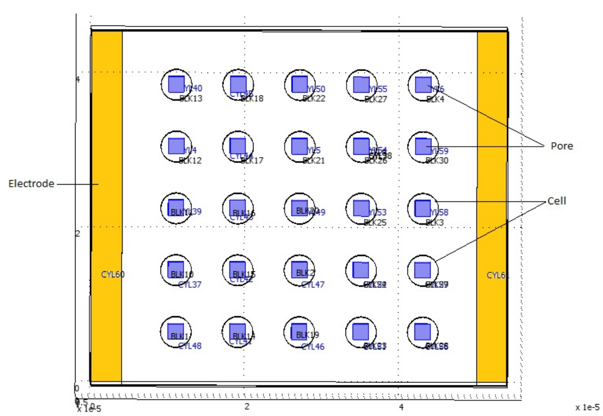

Figure 1: Top view of cells on top of the pores with rectangular electrode

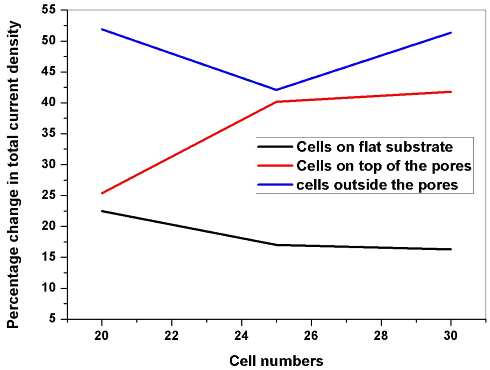

Figure 2: Percentage change in total current density for rectangular electrode

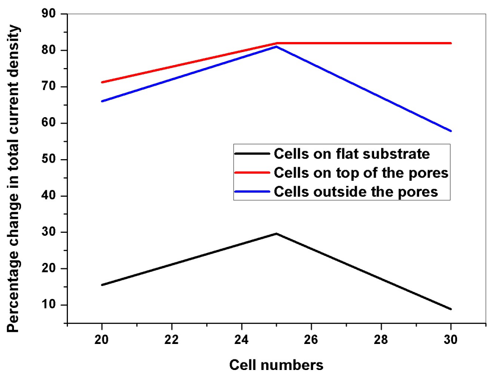

Figure 3: Percentage change in total current density for circular electrode