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Derivation of Mathematical Model Based on Tafel Equation Explains Microbial Fuel Cell Performance

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ABSTRACT

The aim of this work was to establish a mathematical model based on Tafel equation to quantitatively relate the maximum volumetric power ($P_{V,max}$) as well as the internal resistance (R_{int}) in a Microbial Fuel Cell (MFC), with the specific surface area of the graphite anodes (A'_s), and either their conductance C or electrolytic conductivity σ of the material.
The *MFC* consisted of a horizontal cylinder built in Plexiglas 80 mm long and 57 mm internal diameter. The anodic chamber was packed with the different anodic materials (graphite rod (*GR*), triangles of graphite (*GT*) and graphite flakes (*GF*))
The R_{int} were 795, 410 and 273 Ω for *GR*, *GT* and *GF*, respectively, whereas the $P_{V,max}$ were 1326, 2108 and 3052 mW/m^3 for *GR*, *GT* and *GF*, respectively. There was a correspondence of either the decrease of R_{int} or the increase of $P_{V,max}$ with the increase of the log of A'_s of the graphite anodic materials. Here we show the detailed derivation of a mathematical model for the $P_{V,max}$ and R_{int} based on Tafel equation for the cell potential; it lead to equations that exhibited a good correlation with experimental results.
The best fitting models for $P_{V,max}$ were $P_{V,max} = a_0' + a_1' * \log A'_s$ and $P_{V,max} = a_0' + a_1' * \log A'_s + a_2' * \log C$ with determination coefficients 0.8872 and 0.9810, respectively. On the other hand for R_{int} the best fitting models were $R_{int} = b_0' + b_1' * \log A'_s$ and $R_{int} = b_0' + b_1' * \log A'_s + b_2' * \log C$, with determination coefficients 0.8850 and 0.8904, respectively. In general, the inclusion of the electrolytic conductivity did not improve model fitting, whereas the inclusion of conductance lead to a higher determination coefficient in the P_V model but not in the model of R_{int}.

Keywords: Mathematical Model, Volumetric Power, Microbial Fuel Cells