497f Sustainable Power Measurement for a Microbial Fuel Cell

Joseph Anthony Menicucci Jr., Haluk Beyenal, Enrico Marsili, Raaja Raajan Angathevar Veluchamy, Goksel Demir, and Zbigniew Lewandowski

Power generated by microbial fuel cells (MFCs) is computed as the product of the potential difference across the cell and the current in the external circuitry. If the entire system (the cell and the external circuit) is at steady state, the power generated by the MFC and the power consumption are sustainable. The sustainable power generated by the fuel cell depends on the ratio of the external and internal electrical resistances. When the electrodes of a fuel cell are connected through a resistor, current flows. The current is affected by the potential of the cell and by the electrical resistance. The electrical resistance has two components: external, the circuitry powered by the fuel cell, and internal, the fuel cell itself. Initially, before the external circuit is connected to the cell, the potential of the cell reflects thermodynamic equilibriums of the anodic and cathodic reactions. If the external circuitry has a relatively low electrical resistance, the equilibrium potential of the cell initially generates a high instantaneous electric current, higher than the maximum sustainable rate of charge transfer to the current limiting electrode. As a result, the potential across the cell decreases quickly and adjusts to the rate of charge transfer to the current limiting electrode; effectively decreasing the current in the external circuitry. On the other hand, if the external circuitry has a relatively high electrical resistance, the equilibrium potential of the cell generates the electric current lower than the maximum sustainable rate of charge transfer to the current limiting electrode. The potential of the cell adjusts to the external resistor. In the latter case, the power generation is sustainable but lower than it could have been if the resistance of the external circuit was lower.

Power generation by microbial fuel cells is at a maximum when the rate of charge transfer to/from the current limiting electrode is at a maximum; we call this power the maximum sustainable power (MSP), and we use this power to determine what external devices can be attached to the fuel cell and the maximum power the cell can deliver continuously. Predicting the external resistance that is associated with the maximum sustainable power in MFCs is difficult because the operator has limited influence on the main factor that controls power generation: the rate of charge transfer at the current limiting electrode. To avoid these difficulties, and to utilize the maximum power of MFCs, we have designed an empirical procedure to predict the maximum sustainable power. This procedure characterizes the best possible way to operate a fuel cell. The procedure is simple, the fuel cell can be characterized within an hour, and the results of the measurements can serve many purposes, such as: (1) comparing power generation in various MFCs, (2) comparing power generation in MFCs using different electro active reactants, (3) quantifying the effects of the operational regime on the power generation in MFCs, and (4) the purpose for which it was designed, optimizing the performance of existent MFCs.