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Combined Bioelectrochemical-Electrical Model of a Microbial Fuel Cell

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Dynamic mathematical models represent a useful tool in portraying unsteady-state behavior and understanding fundamental properties of microbial fuel cells (MFCs). Recently developed models are able to adequately describe long-term behavior of MFCs operated with a fixed external resistance. These models, however, do not account for the double layer capacitance effect and complex non-linear dynamics observed in most recent experiments, in particular tests involving pulse-width modulated connection of the external resistance (electrical load). To further extend our understanding of MFC dynamics, a combined bioelectrochemical-electrical model (CBE model) obtained by adding fundamental equations based on mass and electron balances with equations describing an equivalent electrical circuit has been developed.

The CBE model of an MFC considers two microbial populations (electricigenic and methanogenic) with kinetics governed by double Monod terms. Anodic biofilm formation is accounted for by limiting the maximum attainable concentration of the microorganisms. Direct contact, nanowires or a mediator-based electron transfer mechanism from the carbon source (acetate) are assumed and the electron transfer by the electricigenic bacteria is considered to involve the oxidized and reduced forms of an intracellular mediator (e.g. NADH/NAD+). On the other hand, a non-limiting cathode reaction rate is assumed. Finally, the CBE model describes the double layer capacitance, which is assumed to be related to the accumulation of biomass at the electrode and is described by a corresponding capacitor dynamic equation incorporated into the electrochemical balance. Consequently, CBE model is capable of describing both fast (milliseconds) and slow (hours and days) dynamic behavior observed in MFCs.

[*Podium presentation*]