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IONIC TRANSPORT IN MICROBIAL FUEL CELLS AND ITS ROLE IN DESIGN OPTIMIZATION

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Anode-respiring bacteria (ARB) catalyze the complete oxidation of organic compounds (e.g. acetate, glucose) into electrical current and carbon dioxide in microbial fuel cells (MFCs). ARB produce a biofilm at the electrode surface, where even cells on the outer part of the biofilm are participating in current production. Our team uses a variety of electrochemical techniques in order to characterize electron and ionic transport responses from various ARB. While the topic of electron transport is the focus of most ARB research, ionic transport is the most important factor in determining rate-limiting and potential loss processes. ARB require near-neutral pH in the medium to grow, differing from chemical fuel cells commonly employed, which run under acidic or alkaline conditions. This pH requirement results in a major transport limitation, as H^+ ions (now in μM range) should be transported from anode to cathode to achieve electron neutrality. In an MFC anode, H^+ ions accumulate in the ARB biofilm, creating an acidification that limits current generation. At the cathode, local gradients leading to pH > 12 is typical in MXC operation; as a consequence, the pH gradient results in Nernstian concentration overpotential of > 300 mV. Thus, understanding and controlling ionic transport in MFCs is essential to ensure an efficient operation. Using this knowledge, we have optimized MFC designs for wastewater primary sludge treatment while concomitantly producing hydrogen peroxide.