Working towards energy sustainability of the water infrastructure using microbial fuel cell technologies

By

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Abstract
Certain naturally occurring microorganisms, called exoelectrogens, are capable of electron transfer outside or into the cell. These microorganisms are being used in several new technologies, based on microbial fuel cells (MFCs), to produce energy and clean water. In an MFC, exoelectrogenic bacteria oxidize organic matter and release electrons to an electrode (anode). These electrons flow to the counter electrode (cathode) where they combine with oxygen and protons to form water, generating current and power. Sustained electricity generation is possible using virtually any type of biodegradable organic matter including pure compounds (acetic acid and other volatile acids, glucose and sugars, amino acids and proteins, etc.), complex organic matter in wastewater (domestic, animal, food, and other industries), and agricultural materials (cellulose and fermentation endproducts). By modifying the MFC architecture it is also possible to accomplish water desalination without any electrical input or high pressures, and to generate electrical power. In the absence of oxygen, and by adding voltage to that produced by the bacteria, hydrogen gas can be generated at the cathode in a device called a microbial electrolysis cell (MEC). The voltage needed (>0.2 V) is substantially smaller than that needed to electrolyze water. For certain substrates, hydrogen gas produced can be recovered at nearly 100% of the stoichiometric yield in an MEC, and two to four times more energy is recovered as hydrogen gas than used as electrical energy. By using electrotophic microorganisms on the cathode, it is possible to produce other products from the current such as methane. In this presentation, I review what is known about exoelectrogenic and electrotophic microorganisms, summarize advances in increasing current densities and reducing materials costs, and discuss recent field trials using larger, pilot-scale MFC and MEC systems that one day may make it possible to provide the energy needed for our water infrastructure.

Bio
Bruce Logan is the Kappe Professor of Environmental Engineering at Penn State University, and Director of the Engineering Energy & Environmental Institute. He has published over 250 journal papers and several books, including one on microbial fuel cells, and works in a variety of research areas including bioenergy production, bioremediation, environmental transport processes, colloidal dynamics, and microbial adhesion. Dr. Logan was recently awarded the Athalie Richardson Irvine Clarke Prize for his research to develop an energy sustainable water infrastructure. He is a visiting professor at Newcastle University in England, Harbin Institute of Technology and Dalian University of Technology in China, and an Investigator with the King Abdullah University of Science & Technology (KAUST) in Saudi Arabia.