From Waste to Electricity and Hydrogen Gas: A Novel Power Management Device for Microbial Fuel Cell-Microbial Electrolysis Cell Coupled Systems

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The microbial fuel cell-microbial electrolysis cell (MFC-MEC) coupled system may pose an effective solution to current energy and environmental problems as it links electrically in series two bioelectrochemical devices, the MFC and the MEC, to simultaneously degrade waste and produce hydrogen gas using anaerobic bacteria. A major limitation of current research is that all of the voltage produced by the MFC is applied to the MEC, resulting only in the production of hydrogen gas, when in fact the applied voltage can be varied, allowing for electricity to be extracted from the system as well. Using semiconductor switches and capacitors, a novel and highly-efficient power management device (PMD) capable of varying the applied voltage was developed. By varying the duty cycle of the PMD, electricity and hydrogen gas can be produced simultaneously in various proportions based on commercial demand. Three novel MFC-MEC systems were constructed using plexiglass cubes, stainless steel mesh, cation exchange membranes, and carbon cloth electrodes with reduced spacing to decrease internal resistance. Secondary wastewater effluent and anaerobically-digested sludge obtained from a local wastewater treatment plant were fed to the three MFC-MEC systems. At PMD duty cycles of 1%, 50%, and 98%, the average hydrogen outputs for each system were 0 mL, 9.4 mL, and 19.3 mL respectively, and the load voltages were 1.21 V, 0.32 V, and 0 V respectively. The MFC-MEC system has wide applications, ranging from use in wastewater treatment plants, biomedical devices, and COD/BOD sensing, to deep sea and space exploration and the transportation industry.