Sustainable Energy Production in Microbial Fuel Cells

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Introduction

Traditionally sewage sludge and solid wastes are utilised by anaerobic digestion, with biogas as a useful product. A recently found alternative is the direct electricity production from organic substrates, e.g. energy crops in microbial fuel cells (MFC). Microorganisms cleave the substrates under anaerobic conditions and use an electrode as final electron-acceptor instead of oxygen, iron or nitrate (Figure 1).

High efficiency can be achieved theoretically and most of the substrate's energy is converted to electricity. Some experiments were made in our group to investigate how different microorganisms produce current under changing conditions (different substrates and different constructions of fuel cells).

Experimental Setup

We have been testing single-chamber and two-chamber constructions of MFCs (Figure 2, 3, 4).

As inoculum, both sewage sludge and especially enriched bacteria solutions were used for the tests. Different substrates, including synthetic maize silage (composition see Figure 5), were taken as examples for substrates with high energy content.

To gain information about the condition of the fuel cells, they were monitored both online (current, voltage and redoxpotential) and offline (pH, COD, volatile suspended solids (VSS), volatile fatty acids (VFA), optical density (OD) and gas composition).

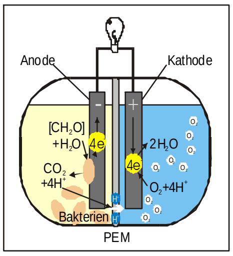

Figure 1: Principle of an MFC

Figure 2: Single-chamber MFC

Figure 3: Two-chamber MFC

Substance	*Amount [mg/L]*
$CaCl_2$	20
KH_2PO_4	6000
$MgSO_4 \cdot 7H_2O$	200
Solution of micronutrients	0,8
Flour	150000
Meatextract	6000

Figure 5: Composition of synthetic maize silage

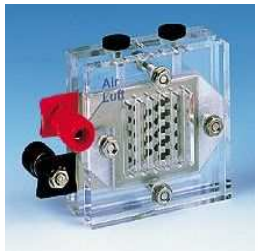

Figure 4: MEA used in a single-chamber MFC

Results

Different conclusions could be drawn from the performed experiments: stable electricity generation from sewage sludge without special inoculation or enrichment of bacteria is possible (Figure 6). Electricity generation is dependent on the pH of the solution and the concentration of volatile fatty acids (Figure 7).

The formation of a functional biofilm on the anode seems to be a requirement for current generation. Power densities up to 160 mW m^{-2}, with a cell voltage of max. 0,4 V could be reached. Moreover, different substrate compositions and concentrations and general conditions for a stable performance in order to increase the power-output were tested. Artificial maize silage, glucose, acetate, and lactate as well as propionic acid are suitable as substrate.

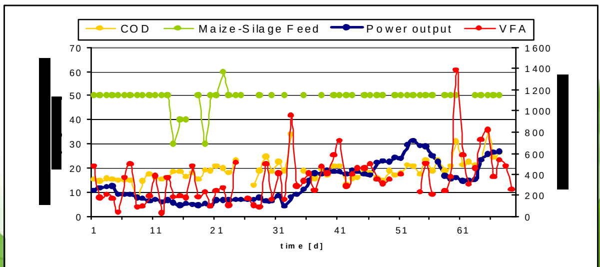

Figure 6: Power output and feed concentration (COD) in a sewage sludge- MFC

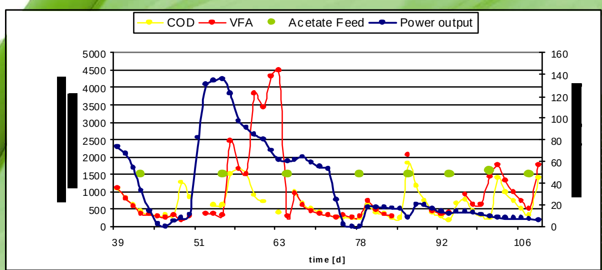

Figure 7: Power output and feed concentration (COD) in a special enriched bacterial culture MFC

Reference

•D.H. Park and J.G. Zeikus. Electricity Generation in Microbial Fuel Cells Using Neutral Red as an Electronophore. Applied and Environmental Microbiology, pages 1292-1297, Lansing, Michigan, April 2000.

•B.H. Kim and H.S. Park. Enrichment of microbial community generating electricity using a fuel-cell-type electrochemical cell. Applied Microbiology and Biotechnology (2004), Issue 63, pages 672-681, Seoul, Korea, August 2003

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