Proposed applications of MFCs in wastewater treatment: a reliable investment?

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ABSTRACT:

Microbial fuel cells (MFC) have a great potential of development in the field of recovering energy in electricity form from wastewater. In this work, we approach in the knowledge of MFCs and study the viability of its possible applications in two cases: a 6 people family house and a 10’000 people town

GOALS of this project:

- Learn and understand MFC mechanism for electrical energy generation
- Find what can MFC technology do to improve wastewater treatment
- Approach to the real development possibilities of MFCs
- Determine whether MFC application is viable in a family house and in a small sized town

21st CENTURY CHALLENGES

- Worlwide growing population at a sustained rate
- Increasing needs for renewable energy:
- Water supply challenge: water availability and pollution are key issues in the today world (1)

MFCs: HOW DO THEY WORK?

- Exoelectrogenic bacteria: a diversity of species and strains is grown, they are anaerobic and generate electricity by transferring electrons to the circuit outside the cell
- Operation of the cell takes place in an anode chamber (electron acceptance) and in a cathode chamber (oxygen reduction), while the generated current flows between the 2 chambers (2)
- Importance of materials and components: membranes, anode, cathode and growing strains have a key role in MFC performance

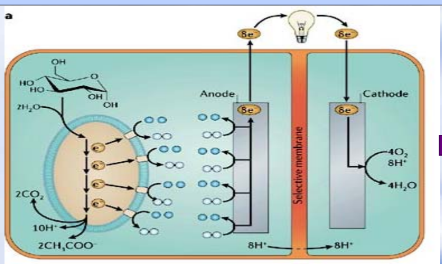

Figure 1: Example of a typical MFC, with anode and cathode chambers separated by the membrane (3)

WASTEWATER TREATMENT PLANTS

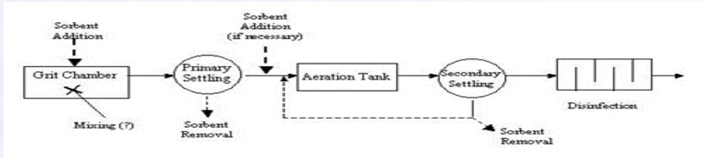

Figure 2: Schematic representation of the WWTP processes, following the activated sludge way (4)

Wastewater treatment plants consists of a series of processes where wastewater goes through and residues are progressively removed. In many of them, a lot of energy is required to perform their activities (5)

MFC USE IN WASTEWATER TREATMENT

Wastewater treatment is the first process where MFC technologies can be applied and developed (2). It is important to notice the hight energetic cost of WWTPs (entirely 1.5% of the US electrical production). Main advantages of MFC over conventional treatment processes include (5):

- Electricity generation
- Saving in aeration costs (when using air cathode), that account for 50% of the total cost in some plants
- Diminution in solid and biomass production, allowing a faster treatment process
- Improvement in unpleasant smell emission to the environment
- Predicted goal of 50% chemical energy recovery from organic matter (1308 kW*s/m3)

OBSERVED PROBLEMS AND LIMITATIONS

- Most of developed MFCs so far have long HRT (processing times) or work discontinuously. It is hard to solve long HRT times as minimization of this magnitude goes opposite to maximization of electrical power generation (5)
- Sludge hydrolysis in MFC can generate volatile acids, that lower the medium pH and affect bacterial growth and electricity generation
- Membranes can suffer fouling, affecting MFC performance. MFC technology has to be improved in order to be stable to power generation at a long-time performance

MFC PERFORMANCE IMPROVEMENTS

- Biocathodes have shown to be effective for catalyzing oxygen reduction without being expensive in terms of fabrication costs, and also an effective and faster removal rate of non-desired compounds (6). What is more, biocathodes show lower internal resistance than other types of cathodes
- AnMBER systems, combining MFCs with an anaerobic microfiltration system, allow a diminution of membrane fouling phenomenon, while achieving higher COD removal rates and higher electricity recovery from chemical energy in the organic compounds (7)

VIABILITY OF MFC APPLICATION

- 2 cases are considered: a 6 people family house and a 10’000 people town

6 PEOPLE HOUSE

- Electricity consumption (8): 26.46 kWh / day
- Treated wastewater volume (9): 1.548 m3 / day
- Maximum generated electricity (5): 0.56 kWh / day
- Estimated money value of generated electricity: 0,10 € / day
- High capital costs for MFC installing and operating (5) (to pay by the people in the house)
- Conclusion: MFC investment is NOT VIABLE

10’000 PEOPLE TOWN

- Electricity consumption (8): 44’100 kWh / day
- Treated wastewater volume (9): 2580 m3 / day
- Maximum generated electricity (5): 937,4 kWh / day (2.1% of electricity consumption)
- Estimated money value of generated electricity: 164 € / day → 60.000 € / year (0.7% of municipal budget)
- High capital costs for MFC installing and operating (5) (to pay by the town council)
- Conclusion: MFC investment is VIABLE depending on technology improvement and development

Conclusion: MFCs applied to wastewater treatment in these 2 cases would not be able to generate a very big amount of power. However, initial investment costs are high for constructing a MFC, so it does not make sense to build it in an individual house. For the global WWT of a town, it is more likely that generated electricity can be used and has a significative value

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