Use of MFC for Wastewater Treatment and Energy Production

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INTRODUCTION

A microbial fuel cell (MFC) is a device that converts biodegradable substrate , glucose, acetate or other forms of organic matter into electricity by bacterial action.

The objectives of this study are to evaluate the viability of having a Flat Plate MFC at home to treat the wastewater and to produce energy at the same time, which could help to reduce the economics of this process.

ANODE

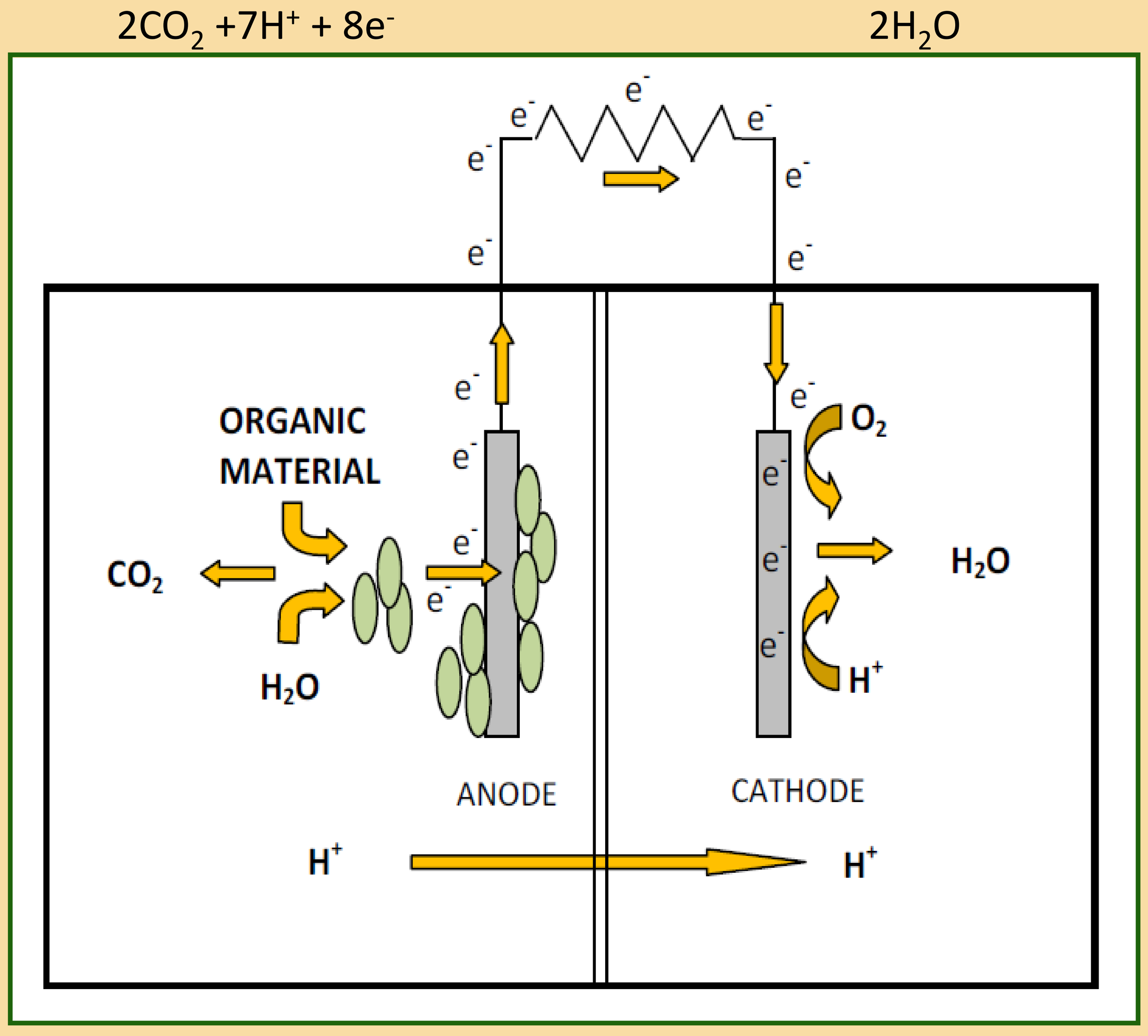
- Anodic materials: conductive, consistent, biocompatible and chemically stable with the environment that feeds the anodic camera.
- The most versatile electrode material is carbon:
  - Granules
  - Graphite
  - Fibrous material
- Oxidation of organic matter.
- Release of
  - Protons to the solution
  - Electrons to the anode
- Biofilm formation

Anode reaction:

$CH_3COO^- + 2H_2O \rightarrow 2CO_2 + 7H^+ + 8e^-$

Cathode reaction:

$O_2 + 4e^- + 4H^+ \rightarrow 2H_2O$



CATHODE

- The choice of cathode materials greatly affects the performance and is different depending on the type of MFC.
- The most used electrode material is carbon or platinum.
- Formation of water by protons and oxigen from the solution.
- Opened to the air, no need of aeration.

MEMBRANES

- Semipermeable to protons
- Impermeable to gases
- Membrane materials: polymers

REAL CASE

Differences between countries are very important depending on their level of development.
We have analyzed the amount of water and energy consumed annually in a home, the amount of COD this water has and the consumption of electricity per year.
There are certain requirements for discharges from urban wastewater treatments that have to be applied.
Advantages of using an MFC instead of a conventional bioreactor:

- Production of a useful product in the form of electricity.
- Lack of a need of aeration because uses only passive oxygen transfer at the cathode.
- Reduced solids production.
- Potential for odor control.

Data of Consumption and COD	
Water (L/home·day)	1000
Electricity (KWh/year)	10949
COD (mg/L)	300

TYPE OF BIOREACTOR USED AND RESULTS

- It was used a FPMFC reactor, because the maximum power density obtained was 72 mW/m^2 for domestic wastewater. That represents an increase by a factor of 2.8 compared to that previously obtained under continuous flow conditions with a different type of reactor (single chambered MFC)
- In Barcelona, the wastewater contains about 300mg COD/L, an average power density of 60mW/m^2 can be achieved with a removal rate of COD about 5.4 mg/L·min.
- Using this information we can determine the volume of the FPMFC and the kWh produced by the amount of domestic waste water consumed in a house.

$$\text{COD removal} = \frac{5.4\text{mg}}{\text{L}\cdot\text{min}}\cdot 0.5\text{h}\cdot\frac{60\text{min}}{1\text{h}} = 194.4\frac{\text{mg}}{\text{L}}$$

$$\text{COD removal rate (\%)} = \frac{194.4}{300}\cdot 100 = 64.8\%$$

$$\text{HRT} = \frac{\text{L}}{\frac{\text{Flow}}{\text{house}\cdot\text{h}}\cdot\frac{1}{\text{A}}} = \frac{\text{L}}{\frac{4000\text{ cm}^3}{\text{house}\cdot\text{h}}\cdot\frac{1}{28}} = 0.5\text{ h}$$

$$\text{L} = 714.28\text{ cm} = 7.14\text{ m}$$

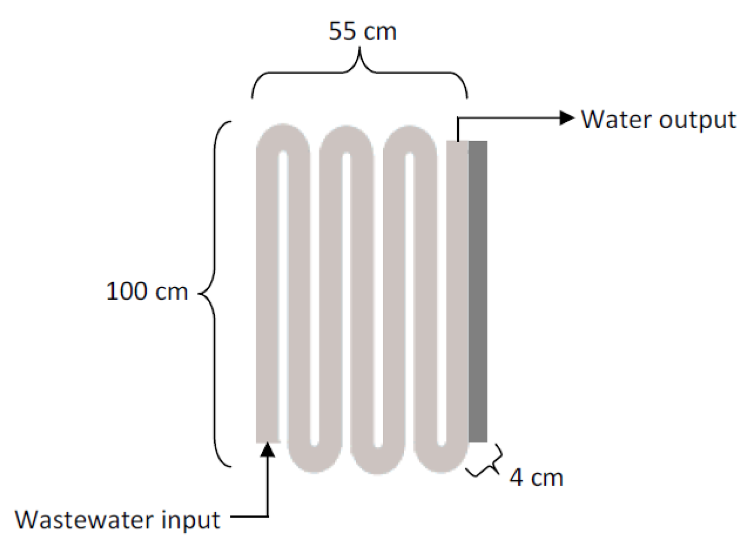
$$\text{Electrode area} = \text{L}\cdot 7 = 714.28\cdot 7 = 5000\text{ cm}^2 = 0.5\text{ m}^2$$

$$60\text{ mWh}\cdot\frac{8760\text{ h}}{1\text{ any}} = 52560\frac{\text{mWh}}{\text{year}\cdot\text{house}} = \frac{0.525\text{ KWh}}{\text{year}\cdot\text{house}}$$

$$\text{Power density} = \frac{60\text{ mW}}{\text{m}^2}\cdot\frac{0.5\text{ m}^2}{0.5\text{ h}} = 60\text{ mWh}$$

$$\text{\% recovered energy} = \frac{0.525\text{ KWh produced}}{10949\text{ KWh consumed}}\cdot 100 = 0.0048\%$$

COD removal rate (%)	64.8
Length (m)	7.14 m
Electrode area (m^2)	0.5
Power density obtained (KWh/year·house)	0.525
Energy recovered (%)	0.0048



CONCLUSIONS OF VIABILITY

- Using a Flat Plate Microbial Fuel Cell (FPMFC) like the one designed previously it's possible to treat the water consumed in a household per year obtaining a COD removal rate about 64.8%.
- It is possible to generate power density, but in a very low yield.
- Using a FPMFC with a surface area of 0.5m^3, the power density obtained is about 0.525KWh/year·house, which is a 0.0048% of the total energy consumed.
- After this study, we can conclude that nowadays it is not viable to install a FPMFC at home because the gains do not outweigh the costs of installing a FPMFC to treat domestic wastewater.
- Further investigation is needed to optimize this technology.

In the future, processes that can generate electricity during domestic and industrial treatment will help to reduce the economic burden of treatment and provide access to sanitation technologies throughout the world.

RELEVANT LITERATURE

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