# Master's Thesis Engineering Technology

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# *Characterisation of electrode size regarding **upscaling** in **microbial fuel cells** for optimising bio-electricity harvesting*

Hendrik Emonds

**Specialization** Master of Electrical Engineering

## Introduction

Due to climate change and the **growing need for energy**, it is necessary to shift power generation towards renewable and environmentally friendly sources. Studies have shown that specific **bacteria** like *Geobacter sulfurreducens* or *Shewanella oneidensis* can **generate electricity** while feeding on organic waste. These bacteria live in anaerobic conditions underground, such as the bottom of streams and plants. It is possible to take advantage of the abilities of these bacteria; a (Plant) **Microbial Fuel Cell** (PMFC) system sustains the bacteria with nutrition from plants, and is able to **harvest electrical power** from the same bacteria. **X-LAB** at Hasselt University tries to optimise the advantages of these MFCs. The goal of this master's thesis is to investigate the **effects of the electrode size** in a MFC to the electrical power output and the MFCs electrical characteristics.

## Methods: Impedance spectroscopy

Many **different configurations** and materials can be used to make a MFC (Fig 1). **Electrical impedance spectroscopy** is used to determine the internal resistances of a MFC. This method uses a small **AC signal with varying frequency** to define the impedance of the system as a function of the frequency to obtain the different electrical system components. Developing an accurate **equivalent circuit model** of the system is a crucial task in this thesis to investigate its role towards future **upscaling** activities.

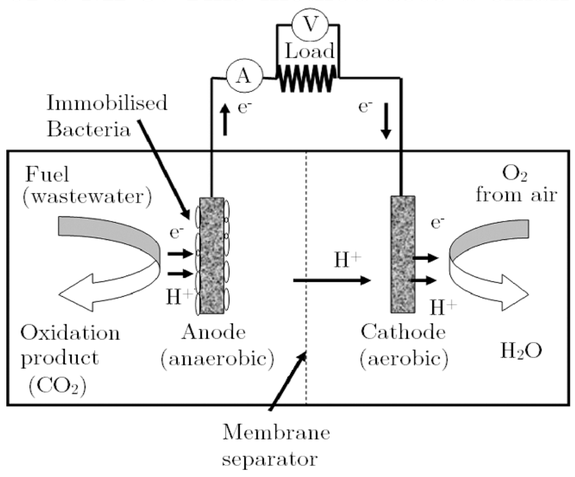


Figure 1: Example of a two-chamber MFC [1]

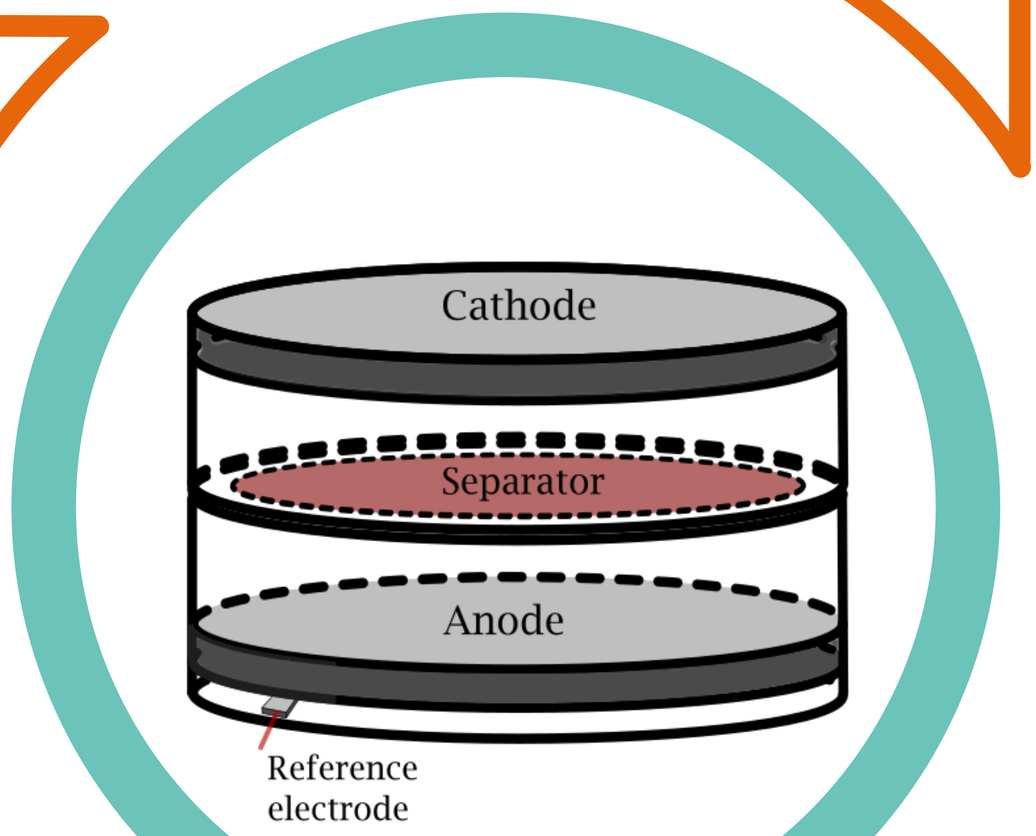


Figure 2: proposed lay-out for test structure

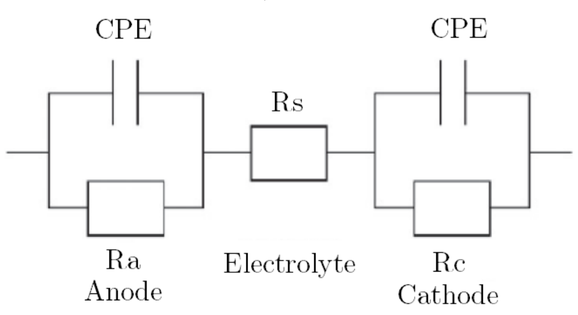


Figure 3: Equivalent circuit model [2]

## Results

First three **test matrices** were designed (Fig. 2) to measure the **influence** of the electrode size on the electrical power output of the system. The parameters can be varied easily due to the optimised setup. Successful **fits in ZView** were obtained by using the equivalent circuit model represented in Fig 3.

**Multiple fits** were excecuted on data of different buffer concentrations to **confirm** the **equivalent circuit** found in literature. The **Nyquist plot** in Fig. 4 shows a data analysis of the electrical response of the anode. A fit to this data using the equivalent circuit model of Fig. 3 is plotted. Since the fit approximates the data clearly, the **equivalent circuit model** is **validated**. Tests on electrode size could not be performed, but a **protocol** is written as a **roadmap** to perform experiments on the different scaled MFCs in the optimised designs.

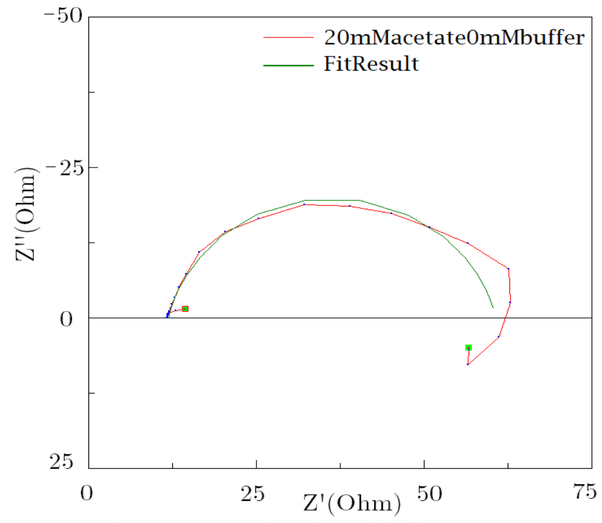


Figure 4: Nyquist plot with fit

## Conclusion

- Fits in ZView show that the proposed **equivalent circuit model is valid** for MFCs.
- **Protocols** to execute experiments on H-cells and SMFCs were written successfully.
- Investigating a method to **quantify efficiency** and **electrical power** output of MFCs is necessary.
- **Experiments** on different MFC systems following the written experiment protocol can give more conclusive answers **in future research**.

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[1] N. Mokhtarian, M. Ghasemi, W. R. Wan Daud, M. Ismail, G. Najafpour, and J. Alam, "Improvement of Microbial Fuel Cell Performance by Using Nafion Polyaniline CompositeMembranes as a Separator," Journal of Fuel Cell Science and Technology, vol. 10, p. 041008-2,7 2013.
[2] Z. He, F. Mansfeld, "Exploring the use of electrochemical impedance spectroscopy in microbial fuel cell studies,"Energy and Environmental Science, vol. 2, p. 216, 1 2009.

X-LAB CROSSOVER RESEARCH & EXPLORATION

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