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Master of Science HES-SO in Life Sciences

Biofilm Structure of *Sporomusa ovata* on Electrode

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DESCRIPTION

Microbial electrosynthesis (MES) is a promising bioelectrochemical system. In this process, gaseous CO_2 is reduced in different valuable chemical compounds such as acetate or methane via bacterial catalysis.

This system works employing specific bacteria so called electrotrophes. These bacteria can consume electrical current as main electron sources directly from a solid surface (e.g. electrode).
To obtain the best production yield, the electrotrophes bacteria need to form a biofilm on the electrode surfaces. The generated biofilm can directly take electrons from the electrode and reduce CO_2 present in the medium into acetic acid. Biofilm formation is a crucial parameter for understanding the process. Nevertheless, few studies have been focused on its development and how to enhance it.

The most studied organism for MES system is *Sporomusa ovata*. This electrotrophe strain is a gram-negative acetogen. In the literature, high conversion of electrons into acetic acid has been achieved (<90%) [1]. However, in various studies this organism has shown poor capacity to build biofilm on carbon electrodes.

Some progress has been made on the electrode material to help *S. ovata* to develop on it. Modified electrodes have shown a thicker biofilm that can reach a width of 25 µm [2]. Nevertheless, biofilm characteristics and influence of process parameters have been poorly described.

OBJECTIVES

The goal of this study is to characterize biofilm development under different conditions.

The conditions evaluated were:

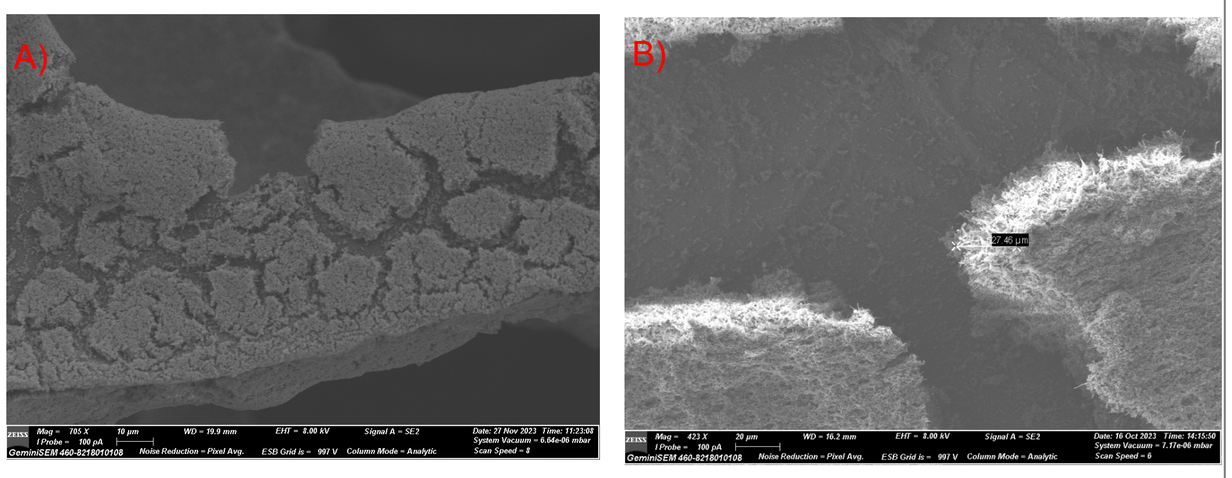
- RVC electrode at -410 mV, -960 mV and -760 mV vs Ag/AgCl 3 M KCl
- Graphite paper electrode at of -410 mV, -960 mV and -760 mV vs Ag/AgCl 3 M KCl
- Reverse cultivation in a microbial fuel cell set-up
- room temperature vs 35 °C cultivation

The biofilm thickness was assessed using scanning electron microscopy and DNA quantification. Measurement of double layer capacitance was also prospected to evaluate the biofilm thickness.

The efficiency of the biofilm and its electroactive activity were assessed via acetate quantification by HPLC and coulombic efficiency measurement via chronopotentiometry.

Each experiment was conducted in a two-chambers glass reactor separated by an anion exchange membrane, the cathode was filled with DSM 311 medium and the anode with phosphate buffer 0.1 M pH 7.0.

RESULTS



Biofilm observed on A) RVC electrode in MFC set-up; B) graphite paper electrode on MES set-up

The thickness observed varied within the same experimental condition, due to an inhomogeneity of the biofilm distribution on the electrode surface, as observed by SEM.

This disparity showed some parts of biofilm more developed than others. This was due to the insufficient experimental time for full biofilm maturation.

However, a positive trend can be observed among the different conditions, showing a thicker biofilm for graphite paper experiment compared to the RVC experiment. Furthermore, the MFC set-up and cultivation at 35 °C temperature showed improvement compared to RVC in the standard process.

Summary of biofilm thickness by experimental conditions

	RVC electrode	Graphite paper electrode	MFC cultivation	35 °C cultivation
Thickness [µm]	1.5-3	5-25	3-5	3-8

The global efficiency of the MES experiment showed similarity among the different conditions.

The best CE were obtained with RVC electrode at room temperature with -410 mV.

The cultivation at 35 °C showed low CE due to the reduction of CO_2 solubility in the medium.

Graphite paper electrode showed similar results except for the -760 mV experiment.

Summary of coulombic efficiency of the process for the different experimental conditions

Reactor	Average CE [%]
RVC at -760 mV	22.1
RVC at -410 mV	31.3
Paper graphite at -410 mV	28.4
Paper graphite at -760 mv	25.8
Paper graphite at -960 mV	28.8
RVC at room temperature	32.0
RVC at 35°C	23.0

CONCLUSION

- In conclusion, the impact of electrode material on biofilm development was observed. The thickness reached higher values with graphite paper than unmodified RVC electrode. For future prospect, modified RVC surface needs to be tested.
- The different potential tests have shown no impact on the biofilm development. Nevertheless, the applied potential influenced the production yield of acetate and the coulombic efficiency of the process.
- The cultivation in microbial fuel cell set-up has shown an increase in biofilm thickness. This experiment showed also a decrease in the biofilm formation starting time. Further research is required on this experiment as it is the first one conducted with *S. ovata*.
- The temperature showed an impact on the biofilm development with an increase in cell number observed at 35 °C, but a decrease in the efficiency of the process.

[1] Flexer, V., Jourdin, L., Purposely designed hierarchical porous electrodes for high rate microbial electrosynthesis of acetate from carbon dioxide, Accounts of Chemical Research, vol.53, (2020)

[2] Kazemi, M., Biria, D., Rismani-Yazdi, H., Modelling bio-electrosynthesis in a reverse microbial fuel cell to produce acetate from CO_2 and H_2O, Physical Chemistry Chemical Physics, vol.17, (2015)