Proceedings of EFC2015
European Fuel Cell Technology & Applications Conference - Piero Lunghi Conference
December 16-18, 2015, Naples, Italy

EFC15267

GELATIN AS A PROMISING PRINTABLE NUTRIENT FEEDSTOCK FOR MICROBIAL FUEL CELLS (MFC)

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***Abstract* – This study describes the work carried out towards the optimization of critical MFC components with potential 3D fabricated materials. The response of the optimised fuel cells, which were fed with soft materials such as gelatin, alginate and Nafion™, is also reported. The optimised components were the membrane and the cathode electrode. Membrane was substituted with a custom made terracotta sheet and the electrode used was a single sheet of carbon veil coated with an activated carbon paste. The results showed that amongst the soft materials tested, gelatin performed better; also it revealed that even after a 10-day starvation period the gelatin had better longevity. These results show that MFCs can be potentially 3D-printed monolithically using the EvoBot platform.**

***Index Terms* – MFC, EvoBot, Gelatin, Nutrient feedstock**

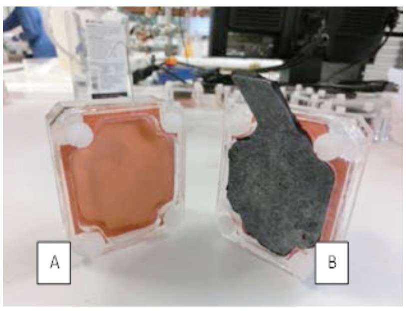
I. Introduction

Microbial Fuel Cells are energy transducers, which convert chemical energy stored in organic matter into electricity through bacterial digestion [1]. MFCs consist of two parts, the positive cathode and the negative anode. The two parts are separated by a semi-permeable membrane, which only allows ions to go through. The key to simplifying the construction of MFCs and making them more accessible is using 3D fabrication techniques and this is the aim of the EvoBot platform [2]. At first, the optimisation of the fuel as well as the membrane is needed, to make it suitable for 3D printing. This study presents the results from MFCs fed for the first time with soft materials as a nutrient feedstock. The cells had open-to-air cathodes and a single layer of terracotta clay as the membrane.

II. Materials and Methods

Twelve analytical-type MFCs with laser-cut acrylic compartments, open-to-air cathode half-cells and 25 ml anodes, were built for this experiment (Figure 1). The cells were constructed using a flat terracotta sheet (2mm) fitted as a membrane and a single sheet of carbon veil coated with activated carbon paste as the cathode electrode. The anodes were made of carbon fibre veil with a total surface area of 270 cm^2 (PRF Composite Materials, UK). MFCs were inoculated with activated sludge derived from Wessex Water (Saltford, UK) and supplemented with tryptone (1%) and yeast extract (0.5%) (TYE). Triplicates of MFCs were fed under continuous flow mode with gelatin, alginate and liquid Nafion ™ respectively; TYE (1:10) was also used as a background solution in all cases.

Figure I



Optimised membrane and cathode electrode MFCs

A. Analytical type MFC with terracotta ceramic membrane

B. Analytical type MFC with activated carbon electrode attached to the ceramic membrane as the air breathing cathode

III. Results and Discussion

The initial response of the MFCs after changing the feedstock from 1.5% TYE to the target substrates is presented below (Figure 2). The MFCs fed with gelatin performed better compared to the other soft materials. The average power production of the MFCs fed with different soft materials is shown below (Figure 3). Although the gelatin output is lower than that of the control MFCs, it appeared to have better longevity, when all MFCs were starved, with its output decreasing at a slower rate than the rest. The long-chain polymer composition of gelatin renders this feedstock longer lasting as it takes longer for the microbes to break it down. The results indicated that gelatin is a suitable feedstock, which could potentially be extruded from the EvoBot platform, and incorporated as a 3D printed substrate for the MFCs. The optimised ceramic-based membrane as well as the cathode electrode paste can also be extruded from the same platform.

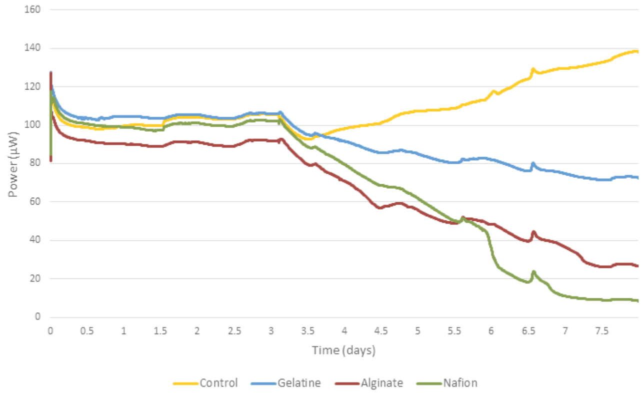


Figure 2: Time profile showing the response of MFCs after feeding with soft materials for the first time. The fuel cells were fed with 1.5% TYE for the first 3 days, and then target soft materials added as a nutrient feedstock.

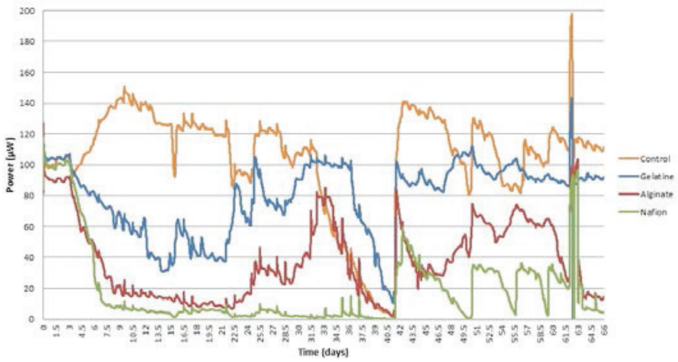


Figure 3: Average power production of MFCs after feeding with different soft materials. The spikes shown during the 62nd day are due to a polarisation experiment. The highest absolute power output for the control was 149.23 µW and for the gelatin 111.26 µW. Starvation period was between the 32nd-42nd days.

IV. Conclusions

Gelatin seems to be a promising soft material that can be 3D printed and used as a feedstock for MFC operation. Flexible materials such as ceramic clay used as a membrane, and activated carbon paste used as a cathode electrode can be used in analytical type MFC with the potential to be 3D-printed. Further work will investigate different material combinations suitable for MFC fuel and compartments, which could be used as part of an entirely 3D printable fuel cell.

Acknowledgment

The authors would like to thank the European Commission for the financial support of this work through the FP7-ICT, grant agreement 611640.

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