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Microbial fuel cell as an alternative for glycerin utilization

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The large amount of glycerin coming from the growing biodiesel industry is demanding an alternative for valorization of this byproduct. Electroxidation in a fuel cell can be an option that combines electricity with the generation of some large added value products (1). Traditional systems are based on the use of metallic catalysts, usually noble metals such as platinum, gold and palladium, limiting its full development due to the high prices and limited availability. One possible alternative are microbiological systems, in which the metallic catalyst is replaced by exoelectrogeneous microorganisms. These donate the electrons produced in the anaerobic oxidation of a substrate to an anodic surface. On the other hand, in the cathode, the oxygen reduction reaction occurs. Ionic charges are transported through the electrolytic anolyte and catholyte solutions, being separated by an ionic exchange barrier that maintains the anoxic anode conditions (2). On this basis, this study presents the results of a microbial fuel cell implemented for glycerol oxidation with simultaneous electricity generation.

The experimental setup consisted of two compartments clamped together forming an H-shape MFC. Between them, a Nafion® 117 membrane was used as proton exchange separator. The volume of both compartments was 230 mL. Graphite bars were used as supporting electrodes. In the anode, a mixed culture of microorganisms coming from the activated sludge of the Wastewater Treatment Plant (WWTP) “Brasília Asa Norte” was used. A previous pretreatment consisted of leaving the sludge for 5 days under complete anaerobic conditions without any feed, in order to promote the growth of anaerobic cultures under endogenous metabolism. In the cathode, 0.5 mg.cm^{-2} commercial Pt/C (BASF Fuel Cells) were deposited on the graphite bar. The surface area of both electrodes was 27.75 cm^2. A volume of 5 mL of synthetic wastewater containing glycerol as carbon source was fed every day, purging 5 mL of the bioanode medium. Solutions of different glycerol concentrations were tested. Chemical oxygen demand (COD) and total suspended solids (TSS) were monitored throughout the experiment. During the acclimation process, the external electric circuit was closed with a 100 Ω resistance. Polarization curves were recorded with a potentiostat/galvanostat μAUTOLAB III at a scan rate of 1 mV.s^{-1}. Anode contribution was determined with the aid of a Reference Hydrogen Electrode (RHE).

Figure 1 shows the results of the acclimation process. It is interesting to observe that from the beginning, a cell voltage of ca. 6 mV was measured. This suggests that after the 5 days pretreatment period, anaerobic microorganisms capable of electroxidizing glycerin grew, and remained stable once placed in the MFC throughout the acclimation process, reflected on a constant cell voltage of approximately 4 mV. This is not the case of the COD and the TSS, which dropt until achieving a stable value after 20 days, due to a slower acclimation rate of the overall microorganism community compared to the exoelectrogenous bacteria. Figure 2 shows the influence of the glycerin concentration in the effluent on the cell performance. As it can be seen, an increase in the substrate concentration leads to larger maximum power densities. Two effects can explain this behavior: i) the larger fuel concentration; and ii) the growth in the exoelectrogenous bacterial community associated to the increase in the substrate availability. The TSS increased the larger the glycerin concentration, so that it may be expected the same behavior for the electricity-producing bacterial community. Furthermore, the treated wastewater COD remained at low values, showing the effectiveness of the MFC for simultaneous COD removal and electricity generation. The anodic polarization curves further supported these observations. A smaller anode potential was measured the higher the glycerin concentration in the feed solution.

1. Z. Zhang, L. Xin, J. Qi, D.J. Chadderdon and W. Li, *Appl. Catal. B-Environ.*, **136-137**, 29 (2013).
2. B. Logan, *Microbial Fuel Cells*, Ed. Wiley-Interscience, USA, 2008.

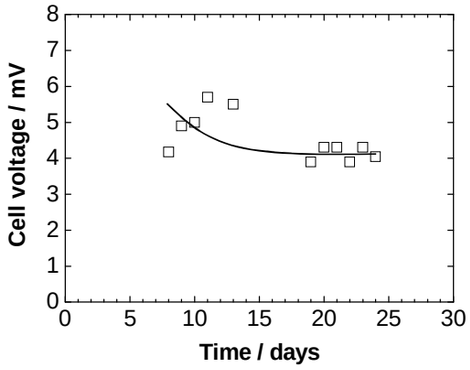

Figure 1. Monitored cell voltage during the acclimation process (electric circuit closed with a 100 Ω resistance). Glycerin concentration during this period was 320 mg.L^{-1}

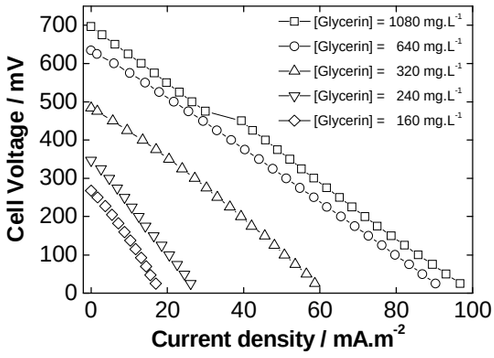

Figure 2. Microbial fuel cell performance for different glycerin feed concentrations