
SYNTHETIC VINASSE TREATMENT AND BIOENERGY GENERATION USING MICROBIAL FUEL CELLS TECHNICHE

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ABSTRACT

Brazil is one of the largest producers of ethanol in the world. However, during the process of ethanol production, large quantities of vinasse are generated which can be harmful to the biota due to its physical and chemical properties. Thus, there is a growing interest in identifying new processes for its treatment. Microbial fuel cells (MFC) are bioreactors whose technology has been considered promising for the treatment of biodegradable waste and simultaneous production of clean and sustainable energy. In this context, our study evaluated the possible application of a double chamber MFC for the vinasse treatment. We observed a reduction in chemical oxygen demand (COD) of 58.8%, and a current density of 330 mWm⁻² in a period of 28 days. Taking into consideration our preliminary results, we concluded that the MFC technology presents itself as highly promising for the treatment of vinasse. However, further studies on the configuration and operation of the MFC are required for a higher number of cycles.

1. INTRODUCTION

Among biofuels obtained from renewable raw materials, ethanol from sugarcane is one that presents a substantial impact on the environment and the quantity produced (Moraes et al. 2014). However, although ethanol is a renewable resource, its production generates a residue – vinasse, and approximately 13 liters of vinasse are produced per liter of ethanol. Vinasse has a low Biochemical Oxygen Demand (BOD₅), high Chemical Oxygen Demand (COD), low pH and is rich in organic and mineral substances, predominantly potassium. This complex composition can cause changes in the physical and chemical properties of soils that receive frequent discharges of this residue, resulting in harmful effects on agriculture and biota (Santos et al., 2014).

The treatment of vinasse through anaerobic digestion is a promising approach, however, such process is still not economically viable (Higa et al., 2014). The use of Microbial Fuel Cell (MFC) technology is considered as a possibility for the biotreatment of this effluent. This technology simultaneously promotes the biotreatment of waste and the production of electrical energy, being environmentally sustainable (Hidalgo et al. 2014).

Although there are studies using several residues in MFC, there are still few reports on the use of this technique for the treatment of vinasse. Therefore, our main objective was to evaluate the possibility of using MFC for the treatment of vinasse and electricity generation.

2. MATERIALS AND METHODS

2.1. Microbial fuel cells design and operation

Three dual chamber MFC type reactors, separated by an ion exchange membrane (Nafion 117, DuPont Co.) with 50 ml working volumes in each compartment, were used. The carbon tissue (2.5 cm x 2.5 cm) was used as an electrode in both compartments, being adhered to a metal screen and connected to a resistance of 500 Ω (Peixoto et al., 2013). The anode compartment was filled with synthetic vinasse (molasses) and inoculated with pure culture of sulphate reducing bacteria (IPT 032) in 2, 4 and 6 mL volumes. The cathodic compartment was filled with synthetic medium. The electrochemical experiments were performed using potentiostat/galvanostat PGSTAT 30 every 24 hours. The sugars were measured by high performance liquid chromatography (HPLC) with an Aminex HPX-87C (300 x 7.8 mm, Bio-Rad Laboratories) column and a system composed by: a 510 pump, a refraction index differential detector, and a data processor with register (Waters, USA).

Chemical oxygen demand was determined every 7 days using HEXIS kit. The experiment was carried out for a period of 28 days.

5. RESULTS

We analysed the variation of the MFC open circuit as a function of time (Figure 1A). According to the results obtained, the relation between the inoculum concentration and the MFC activity observed was direct and linear. The highest values of power density (Fig 1b) were detected in the cell containing the highest inoculum concentration, corresponding to 330 mWm^{-2} . No activity was detected in the control during the study period.

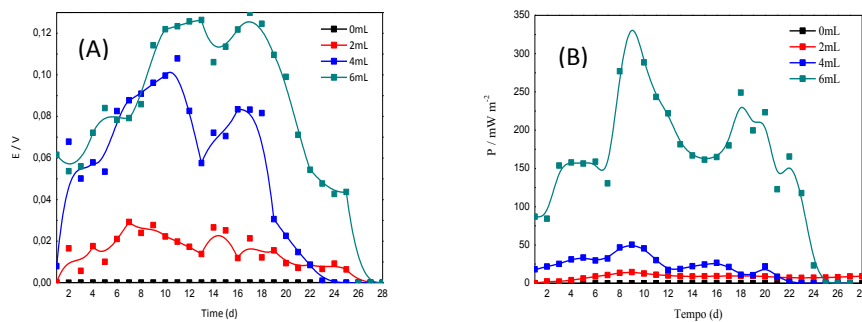


Fig. 1. (A) Variation of open circuit; (B) power density.

The consumption profile of the sugars that compose the synthetic vinasse during the process were also followed (Fig. 2A, 2B, 2C). The time of consumption of the monosaccharides occurred between the 7th and the 14th days, while consumption of sucrose occurred between the 8th and the 21st days.

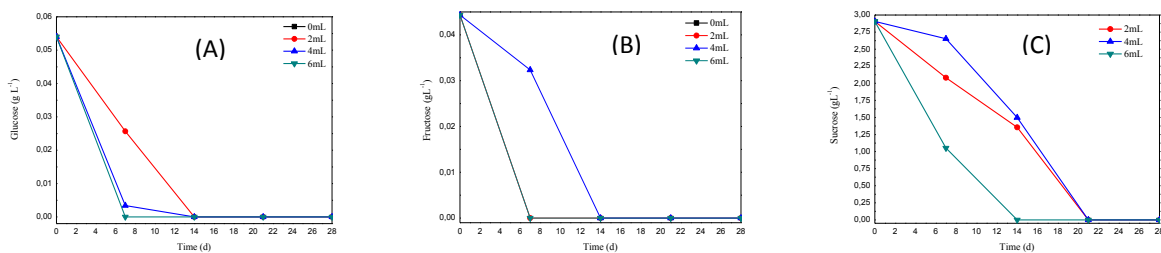


Fig. 2. Consumption of sugars: (A) glucose, (B) fructose, and (C) sucrose.

When analyzing the MFC operation (Fig. 3), we observe a reduction rate of COD at a value close to 58.8% which can be justified by the performance of the experiment being done in a single cycle.

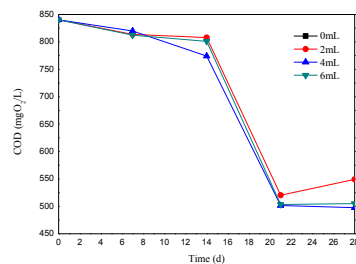


Fig. 3. Reduction of chemical oxygen demand (COD) of vinasse in the MFC, over 28 days of operation.

5. CONCLUSIONS

Through the analysis of our preliminary results, we concluded that the MFC technology presents itself as very promising for the treatment of vinasse. However, further studies on the cultivation of the sulphate reducing bacteria in the anode chamber, on the configuration, and operation of the MFC in a larger number of cycles are necessary.

6. REFERENCES

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