University of Tabriz

Journal of Civil and Environmental Engineering
Volume 52 (2022), Issue 3 (Autumn), 21-27

EXTENDED ABSTRACT

Removal of Phenol and Electricity Generation in Microbial Fuel Cell by Using Microbial Seeds from Wastewater of Oil Refinery

Ramazan Ali Dianati Tilaki [a,*], Morteza Ghalenoei [a], Ghasem Najafpour [b], Masoumeh Eslamifar [a]

[a] *Faculty of Health, Mazandaran University of Medical Sciences, Sari, Iran*
[b] *Faculty of Chemical Engineering, Noshrivani Universityof Technology, Babol, Iran*

Received: 24 July 2017; **Accepted:** 10 January 2021

Keywords:
Microbial fuel cell, Phenol, electricity, Oil Refinery Wastewater.

1. Introduction

Microbial fuel cells are an emerging technology that can convert biochemical energy into electrical energy. The driving force in these cells is the result of oxidation-reduction reactions of an organic substance in which microorganisms are used as biocatalysts. In these cells, the bacteria convert the biodegradable organic matter into electrical energy that is biodegradable. This can both treat wastewater and generate electricity. The main components of a microbial fuel cell are the anode, cathode, proton exchange membrane (PEM) and an electrical circuit. The bacterial population around the anode consumes the organic substrate as food and produces electrons and protons. Electrons are absorbed through the electron transfer chain at the anode surface and transferred to the cathode by an external electrical circuit, resulting in a measurable electric current. The anode part is anaerobic and the cathode part is aerobic (Logan et al. 2006). In the effluents of oil refineries and petrochemicals, there is phenol and its derivatives that cause environmental pollution. On the other hand, in the wastewater treatment system of these industries, there are natural bacteria that cause the biological decomposition of phenolic compounds (Luo et al. 2009). According to the literature, research has been done to remove phenol in the microbial fuel cell, but none of them used the microbial seeds of a refinery wastewater treatment plant. By conducting this research, using this type of microbial seed, the decomposition of phenol and electricity produced in the microbial fuel cell was investigated. The purpose of this study was to determine the rate of decomposition of phenol and electricity produced in microbial fuel cells using microbial seeds obtained from wastewater treatment plants of oil refineries.

2. Methodology

The fuel cell used in this study was a two-chamber type made by plexiglass and the volume of each anode and cathode chamber was 800ml. The anode chamber was built with a slide gate for feeding and sampling. In the cathode chamber aeration was performed by an aquarium air pump. The two chambers were separated by a proton exchange membrane, Nafion 117 from Dupont Corp. with an area of 10x10cm^2, which was activated 4h at 80°C in four successive stages: first 1h in 3wt % hydrogen peroxide solution, then 1h in deionized water, after that 1h in sulfuric acid (0.5M) solution, and finally 1 h in deionized water. Composition of culture medium (In first stage) in one liter consisting of 13g of nutrient broth, 5.92g Na_2HPO_4, 2.29g NaH_2PO_4, 0.3g NH_4Cl, 0.1gKCl, 0.15g $CaCl_2$, 10ml multivitamin and 10ml mineral solution and then sterilized in autoclave. Mixed

* Corresponding Author
E-mail addresses: rdianati@mazums.ac.ir (Ramazan Ali Dianati Tilaki), microbiologist.eslamifar@gmail.com (Morteza Ghalenoei), najafpour@nit.ac.ir (Ghasem Najafpour), microbiologist.eslamifar@gmail.com (Masoumeh Eslamifar).

liquid suspended solids collected from aeration tank of Tehran oil refinery wastewater treatment plant was used as microbial seeds. In the second stage, 100ml of microbial seed was added to 400ml of the first stage medium and the phenol concentration increased to 50mgL^{-1}; it was then incubated for two weeks on a magnetic stirrer in an incubator at 30°C. At 24h time intervals, phenol concentration was increased to 200mgL^{-1} by adding phenol to the medium. In the third stage, the culture medium of the anode chamber was prepared by mixing in one liter containing 100ml of mixture of the second stage, 20mM sodium acetate, 0.1mM phosphate buffer, phenol 200mgL^{-1}, NaCl 5.84gL^{-1}, NH4Cl 0.3gL^{-1} and KCl 0.1gL^{-1}. 600ml of the third stage culture medium was added to the anode chamber. The cathode chamber was filled with 600ml of 0.1M phosphate buffer solution with pH=7. The oxygen required for cathode was provided by an aquarium air pump.

Fig. 1. Set up of dual chamber microbial fuel cell

3. Results and discussion

Different concentrations of phenol in the amounts of 50, 130, 170, 250, 400, 550, 800 and 1000ppm was injected separately into the anode chamber and the amount of voltage produced as well as the remaining concentration of phenol over time was measured by sampling at different retention times. The results of the

phenol analysis are shown in Fig. 2. Phenol was completely removed at all concentrations for a maximum of 96 hours.

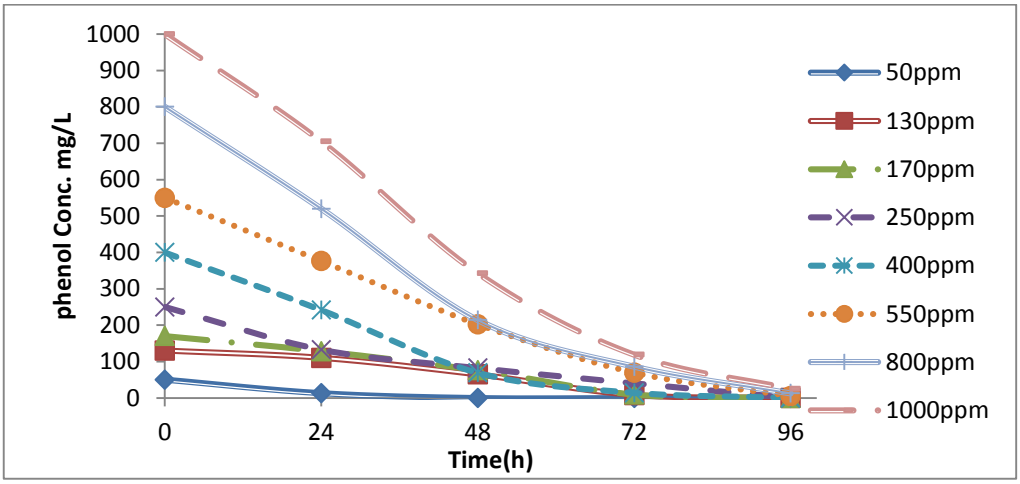

Fig. 2. Change of phenol removal in MFC over different contact time

Microbial fuel cell function over a period of 40 days is shown in Fig. 3. At 5-day intervals, when the output voltage reached about 100 mV, a new culture medium containing 400 ppm phenol was injected into the anode chamber.

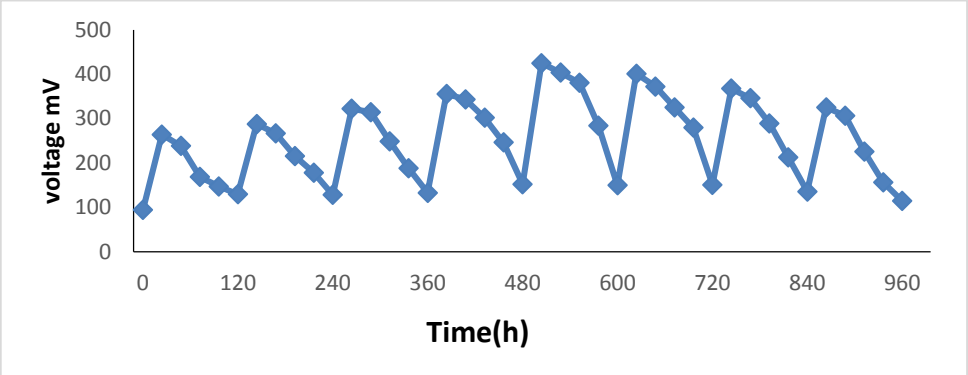

Fig. 3. Voltage changes over time by adding phenol with a concentration of 400 ppm over a period of 40 days

4. Conclusions

Bacterial seeds from sludge of refinery wastewater treatment plant was used for growth of phenol-adapted bacteria in order to add in anode anaerobic chamber of microbial fuel cell. The results showed that these microorganisms have a very good ability to grow under anaerobic conditions and decompose phenol.

5. References

Logan B, Hamelers B, Rozendal R, Schröder U, Jürg K, "Microbial fuel cells: methodology and technology", Environmental Science and Technology, 2006, 40 (17), 5181-5192.

Luo H, Liu G, Zhang R, Jin S, "Phenol degradation in microbial fuel cells", Chemical Engineering Journal, 2009, 147, 259-264.