Iraqi National Journal of Chemistry

Journal homepage:
http://iqnjc.com/Default.aspx

Eco-friendly Microbial fuel cell for conversion west water to electricity

Rana Hadi Hameed al-Shammari

Al- Mustansiriyah University\ College of Science\ Department of Biology *

E mail: rana_ecology@yahoo.com.

Abstract

The depletion of non-renewable energy resources leads us to discover an alternate eco-friendly fuel. Microbial fuel cells (MFCs) considered as completely new ecofriendly approach, affordable and accessible to waste water treatment with production of sustainable electrical energy by converting organic matter into electricity. In this technology we used sewage which successfully generated a power of 0.4 -2.9 V, which is sufficient to a light - emitting diode(LED) and current 0.6-0.85 mA. COD removal efficiency achieved in MFC was 88.4%, TDS removal efficiency was55.5% This technology will be adopted for the future.

Key words: Microbial fuel cell, electricity, waste water, power-generation.

Introduction

A new method for electricity generation and wastewater treatment, which is not only decrease cost but also produce useful side-products, had received international attention in recent years. MFCs are devices that directly convert chemical energy to electricity through the catalytic activities of microorganisms and treat wastewater at the same time [1-2]. MFC is a dual-chamber system, consisting of a cathode and an anode chamber that is separated by a proton exchange membrane (PEM) or salt bridge, membrane or salt bridge allow hydrogen ions (H^+) generated in anode to be transferred into cathode [3], In this case, oxygen must be continuously produced for the reaction in the cathode, as a result more energy consumption for aeration [4]. Therefore, requiring continuous aeration is obviously a limitation for real applications of MFCs because of its environmental and economic cost.

The chemical reactions which are carried out in an MFC using waste water as fuel are given by equations (1) and (2)

Anodic reaction:

$C_6H_{12}O_6 + H_2O \rightarrow 6CO_2 + 24\ e^- + 24\ H^+$ (1)

:Cathodic reaction

$O_2 + 4e^- + 4H^+ \rightarrow 2H2O$ (2)

As a solution to maintain or eliminate minimum energy. consumption for cathode aeration, recent studies have proposed the integration of algal photosynthesis with MFCs, which known as photo MFCs [5-6]. Therefore, the algae-based photo- biocathode is capable of simultaneously carbon dioxide reduction, generating electric energy, and treating wastewater.

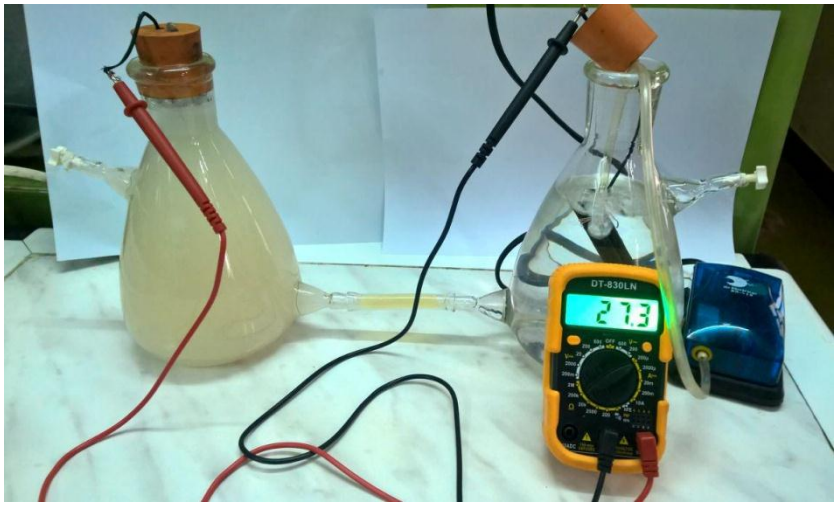
Aim of this study Also a (MFC) was designed for generation of electricity from low-cost materials and completely anoxic microbial fuel.

Materials and methods

MFC construction:

In this study dual chambered MFC is used which consisted of two borosil bottles (1Liter capacity). Agarose salt bridge was used instead of proton exchange membrane (PEM). The salt bridge made of PVC pipe (length=12cm; diameter=2.5cm). Agarose of concentration 10% with 4% Potassium chloride(KCl) salt were dissolved by heating them in a water-bath and the molten agarose was left to cool down and poured into the PVC tube which left for 2 hours undisturbed to solidify. The PVC tube containing the salt-agarose was fixed between the two bottles using epoxy material and behaved like the salt-bridge assisting in the proton transfer mechanism between the two electrodes of the MFC, The PVC tube was stored in 1M KCl solution until the second use.

Both anode and cathode electrodes were made of Graphite plate with dimensions of (14cm x 5cm x1.5 mm). Single copper wire (I.D 0.5mm) were used to connect both electrodes to the external circuit and the readings were measured using a digital multimeter (Model No. DT830D). , constructed dual MFC showed in Picture (1) and figure (1).



Picture (1): Double chambered MFC.

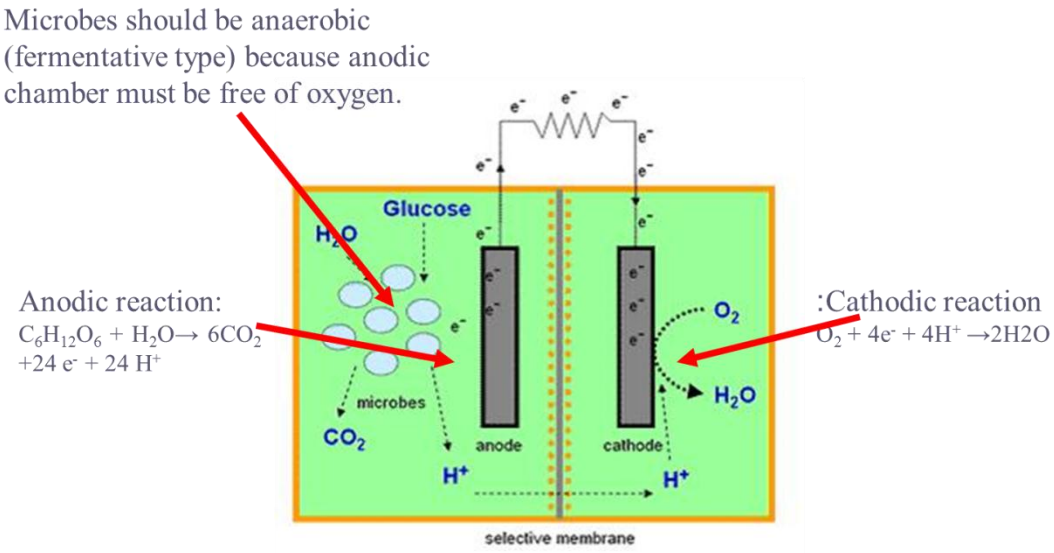


Figure 1: Schematic shape illustrates MFC.

Wastewater samples

The domestic wastewater was collected from Al-Jaeish canal East of Baghdad. Table 1 shows the characteristics of domestic wastewater. Samples refrigerator at $4C^0$ before use. The wastewaters were used as inoculum for all MFC tests without any modifications such as additions of nutrients or pH adjustments . Experiments analytical procedures followed methods in Standard Methods for the examination of water and wastewater characteristics [7].

Table 1: Characteristics of domestic wastewater samples

Parameters	Domestic wastewater
pH	7.1
Colour	Yellowish
Total Solids (mg/L)	1213
Total Dissolved Solids (mg/L)	985
Suspended Solids (mg/L)	188
BOD (mg/L)	223
COD (mg/L)	955
Chlorides (mg/L)	211

Results

Electricity in the MFC was generated using domestic wastewater. The voltage range was 0.4 -2.9 V and current 0.6-0.85 mA as showed in (figure 2). The effect of MFC in wastewater COD and TDS removal efficiency and electricity generation were observed.

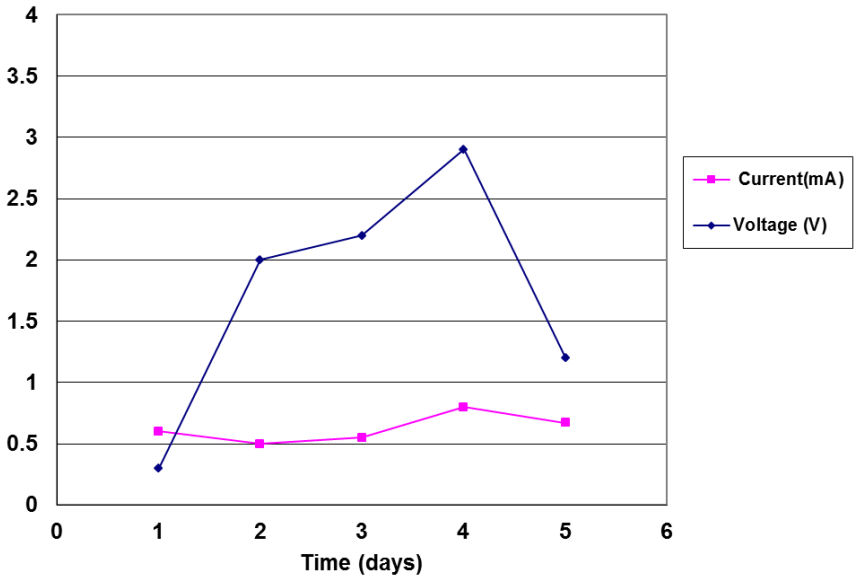


Figure2: Bioelectricity production in MFC.

COD Removal Efficiency

During operation, MFCs was continuously monitored for waste as COD removal to enumerate the potential of fuel cell to act as wastewater treatment unit. domestic wastewater showed its potential for COD removal indicating the function and activities of microbes, present in wastewaters in metabolizing the carbon source as electron donors. Continuous COD removal was observed in MFC during 7 days of operation. Initially full strength wastewater was used in the anodic chamber, evident from experimental data that current generation and COD removal showed relative compatibility. The COD removal effect of domestic wastewater in MFC . The COD removal efficiency using domestic wastewater at 100% concentration was 88.4%. This relative slow COD removal was probably due to less availability of biodegradable substrate in wastewater samples leading to competitive inhibition in microorganisms.

Total Dissolved Solids (TDS) Removal Efficiency

MFC showed its potential for total dissolved Solids removal, The TDS removal efficiency using domestic wastewater at 100% wastewater concentration was 55.5%.

Discussion

This study demonstrated that MFC technology was able to treat domestic wastewater successfully and microorganisms present in the wastewater are responsible for electricity generation and COD and TDS removal.

MFC can be used to generate electricity using an anaerobic cathode and a small applied voltage to reduce protons in the cathode chamber.Recently discovered that hydrogen can be produced from a fermentation end product by modifying a MFC by applying a small potential to that generated by the bacteria [8].

Microorganisms show lower metabolic activity when inhibited by toxic compounds which cause a lower electron transfer towards an electrode. Biosensors could be constructed, in which microorganisms are immobilized onto an electrode and protected behind a membrane. Toxic components which diffuse through the membrane, this can be measured by the change in potential over the sensors which could be extremely useful as indicators of toxicants in rivers, at the entrance of wastewater treatment to detect pollution, contamination or illegal dumping or to perform research on polluted sites [9].

RECOMMENDATIONS

MFC promise towards sustainable energy generation in the future. In addition to having very high fuel efficiency, microbial fuel cells produce very little pollution. They are cheap compared to a full metal combustion engine and they pose no explosion hazards such as the hydrogen fuel cell systems. The combination of wastewater treatment with electricity production may help in saving money as a cost of wastewater treatment.

بطارية حيوية صديقة للبيئة لانتاج الطاقة الكهربائية عن طريق معالجة مياه الصرف الصحي

هادي حميد الشمري

الجامعة المستنصرية/ كلية العلوم/ علوم الحياة*

الخلاصة

ان انحسار مصادر الطاقة الغير متجددة قادتنا الى اكتشاف طرق صديقة للبيئة لانتاج الطاقة .البطارية البايولوجية (MFCs) تعتبر طريقة جديدة صديقة للبيئة والتي يمكن من خلالها معالجة مياه الصرف الصحي وانتاج الطاقة الكهربائية في نفس الوقت وباقل تكلفة مادية ممكنة. في هذه التقنية تم انتاج طاقة كهربائية بنجاح من معاملة مياه الصرف الصحي المنزلية ،اذ تراوحت الطافة المنتجة بين٠.٤-٢.٩ فولت وهي كافية لانارة ضوء LED وتيار كهربائي تراوح بين ٠.٦-٠.٨٥ ملي امبير. نسبة كفاءة ازالة المتطلب الكيميائي للاوكسجين كانت ٨٥% ونسبة كفائة ازالة المواد الصلبة المذابة كانت٥٥.٥% . تعتبر هذه الطريقة تقنية واعدة ويمكن اعتمادها في المستقبل كمصدر للطاقة البديلة

الكلمات المفتاحية: بطارية بايولوجية، كهرباء، مياه الصرف الصحي،انتاج الطاقة.

References

1-Logan B.E, Rabaey, K. 2006. Microbial fuel cells methodology and technology, pp. 11-17.

2-. Logan B. E. and Rabaey, K . 2012. Conversion of wastes into bioelectricity and chemicals by using microbial electrochemical technologies, *Science*, vol. 337, no. 6095, pp. 686–690.

3- Haiping, L., L. Guangli, Z. Renduo and J. Song, 2008. Phenol degradation in microbial fuel cells. Chem. Eng. J., 147: 259-264.

4- He, Z. 2013. Microbial fuel cells: Now let us talk about energy. Environ. Scien.and Technolo., 47(1) :332–333.

5- M. Rosenbaum, Z.He, and L. T. Angenent, 2010. Light energy to bioelectricity:photosynthetic microbial fuel cells," Current Opinion in Biotechnolo., vol. 21, no. 3, pp. 259–264.

6-Y. Zhang, J. S. Noori, and I. Angelidaki, 2011.Simultaneous organic carbon, nutrients removal and energy production in a photomicrobial fuel cell (PFC), Energy and Environ. Scien., vol. 4, no. 10, pp. 4340–4346,.

7-Standard Methods for Examination of Water and Wastewater.1995. 19th Edition. Prepared and Published by American Public Health Association, American Water Works Association, Water pollution control federation.

8- Liu H. Logan B. E. 2004. Electricity Generation Using an Air-Cathode Single Chamber Microbial Fuel Cell in the Presence and Absence of a Proton Exchange Membrane". Environ. Sci. Technol., 38, 4040–4046.

9-Cheng S., Liu H. and Logan B.E. 2006. Increased power generation in a continuous flow MFC with advective flow through the porous anode and reduced electrode spacing". Environ. Sci. Technol., 40,2426-2432.