International Journal of Advanced Science, Engineering and Technology.
ISSN 2319-5924
Vol 2, Issue 2, 2013, pp138-143
http://www.bipublication.com

ROLE OF MODIFIED ELECTRODE ON THE PERFORMANCE OF MICROBIAL FUEL CELL

V. D. Patil[1], D. B. Patil[2], M.B.Deshmukh[3], S. H. Pawar[4*]

1 Department of Applied Sciences, TKIET Warana nagar, Kolhapur-India
2Department of Chemistry, Vivekanand College, Kolhapur- India
3 Department of Chemistry, Shivaji university,Kolhapur, India
*4 Vice-Chancellor, D.Y. Patil University, Kolhapur- India

[Received:25/02/2013, Published: 11/03/2013]

ABSTRACT

Two chamber MFC was used to enrich electrochemically active microbes using activated sludge as inoculum and dairy waste as fuel. The anode modifications used in this work were based on enhancement of active surface area, electrical conductivity without use of any catalysts. This was achieved by depositing PANI on the graphite electrode. The modified graphite materials were characterized by SEM.

The low voltage o.48 V was observed in the two chamber MFC with unmodified graphite electrode as the anode material. The best performance of MFC with the voltage 1.02 V was observed with the modified graphite electrode suggesting that the increase in performance was achieved by modifying the graphite anode with PANI showed good behavior which indicates that the PANI is also effective to increase the electrical conductivity.

Key words: - Microbes, PANI electrodes, Dairy waste, Electricity.

INTRODUCTION

In the recent years, Microbial Fuel Cell (MFC) has been forecasted as a promising technology for the disposal of waste water coming from different industries[1,3,7,10,12,18,28,30,33]. MFCs convert the chemical energy into electrical energy by the oxidation of organic matter present in the waste water. In addition Microbial Fuel Cell may be an environmental friendly energy resource alternative to fossil fuels. It has been known for several years that, microorganisms or enzymes can be used to produce electricity in Microbial Fuel Cells. [15, 27] MFC is typically designed as a two chamber system with bacteria in anode chamber separated from the cathode chamber by an ion conducting membrane [2, 13].

Microbial Fuel Cells convert organic matter into electricity by using bacteria as biocatalysts [4-7, 13, 16, 21-25]. Bacteria at the anode oxidize organic matter and transfer electrons to a cathode through an external circuit producing current[2,14,27,29 ,31] Protons produced at the anode migrate through the solution across a proton exchange material to the cathode where they combine with oxygen and electrons to form water[5,9,13,19,32].Although the basic concept of the Microbial Fuel Cell, aerobic and anaerobic respiration, is more than 5000 years old, its potential applications as an alternative source of energy have only been discovered recently. The progress in fuel cells for their commercialization is restricted mainly because of the production and supply of hydrogen from the external sources. [11, 17].The efforts have been made to use domestic waste water as a substrate for MFCs due to environmental concerns and the need to reuse waste [8, 32]. Anaerobic sewage sludge is supposed to be good microbial source for inoculating a MFC as it is easily obtained from a waste water treatment plant and it contains highly varied bacterial communities that contain electrochemically active strains of bacteria. The majority of bacteria in typical anaerobic waste water sludge are believed to consist of fermentative bacteria, methanogens, and sulfate reducers[20,26,27] . Recently, production and continuous supply of hydrogen in fuel cells is made possible due to microorganisms. The microbial utilization of nutrients results in generation of electrons into medium and gives rise to the flow of electrons into the external circuit. MFCs show promise as a method to treat waste water and to produce electricity at the same time [18, 11, 31]. On the similar line the disposal of waste water from the dairy industry is a severe problem.

Over ten thousand liters of dairy waste water is treated each day in a medium level dairy. The dairy waste is acidic in nature and has the P^H in the range of 3 to 4. In addition, it consists of the organic solid and the volatile matter. They produce methane gas, causes global warming. Thus the dairy waste water treated chemically to bring its P^H to neutral before its disposal for watering the agricultural farm. It consumes large amount of energy .As an alternative, the anaerobic treatment technologies provide potential solution for reducing treatment costs. The anaerobic treatment of dairy waste water has been attempted to produce biogas. However, the reports on treatment of dairy waste water with Microbial Fuel Cell are few to date.

The aim of the present study is to investigate the disposal of dairy waste with MFC and simultaneously exploiting dairy waste for microbial electricity generation, Since the performance of MFC, depends on the nature of microbes, therefore we have attempted the variety of cultures in MFCs such as activated sludge from dairy waste plant, rice field soil, brick factory soil and pure culture (*E. aerogenes).* The performance of MFC formed with dairy waste added with different cultures is studied and the suitable culture with maximum performance of MFC is revealed.

MATERIALS AND METHODS

Material collection

Graphite plate was collected from Omega Carbon, Jaisingpur

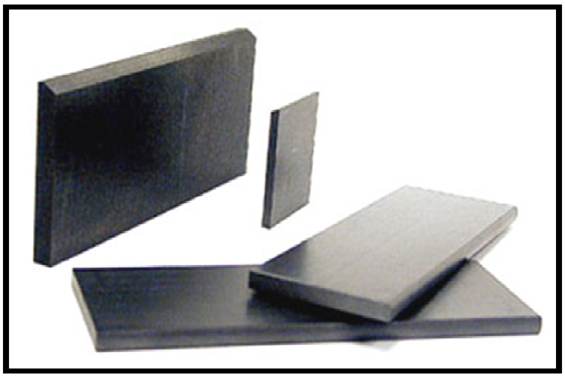
Sample of Dairy waste water was collected from Shree Warana Sahakari Dudh Utpadak Prakriya Sangh Ltd.,Warananagar.

Microbial Culture i.e. *Enterobacter aerogenes* was collected from National Collection of Industrial Microorganisms (NCIM), Pune, strain No. is 2340.

Anode and Cathode

The most versatile electrode material is carbon, available as compact graphite plates, rods or granuels, as fibrous material (felt, cloth, paper, fibers, foam) and as glassy carbon. The anode used was graphite plate.[16]

Fig. 3. 5 Graphite plates



Due to good performance, ferricyanide [$K_3(Fe(CN)_6)$] was used as an experimental electron acceptor in Microbial Fuel Cells. The greatest advantage of a ferricyanide is the low overpotential using a plain carbon cathode, resulting in a cathode working potential close to its open circuit[17].

Aniline was distilled under vacuum and stored in dark. Polyaniline was electrodeposited from 0.1M aniline in 0.1M sulfuric acid solution. A computer controlled Autolab potentiostat PGSTAT20 (Ecochemie, The Netherlands) was used. A single compartment electrochemical cell was employed with graphite as working electrode, Ag/AgCl, KCl (3M) as reference electrode and platinum wire as counter electrode. The polymerization was carried out by potentiodynamic method i.e. by sweeping the potential between -0.2V to +0.8V (vs. Ag/AgCl reference electrode) at a scan rate of 50mV/sec [20]. The deposition was carried out in 50 continuous scans

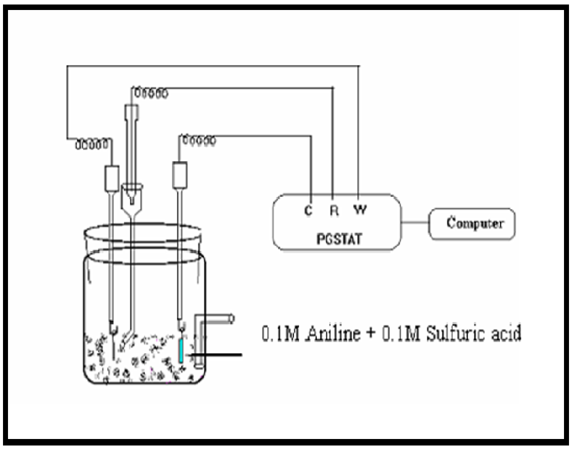


Fig. Electrochemical synthesis of polyaniline

Substrate

Substrate concentration, type and feed rate can greatly affect the efficiency of a cell. Common laboratory substrates include acetate, glucose or lactate, while real world applications to waste water and landfills are also abundant. In the present investigation we used dairy waste as substrate.

Inoculum

Microorganism used : - *Escherichia coli (E.Coli)* NCIM 2319, *Enterobacter aerogenes* NCIM 2340

Salt Bridge

Salt bridge acts as a barrier between the anodic and cathodic chambers.Ideally, no oxygen should be able to circulate between the oxidizing environment of the cathode and the reducing environment of the anode.

The Purpose of an agar salt bridge is to provide an electrical connection to the bath solution while minimizing the transfer of ions or solute from the electrical environment.

Construction of MFC

Microbial Fuel cell is made up of two compartments i.e. Anode and Cathode.

We have used the Glass jars as Anode and Cathode compartment having diameter of 9cm and hight of 17 cm.

Fig. 1 Microbial Fuel Cell

Most of the Microbial Fuel Cell consists of Proton Exchange Membrane i.e. PEM. It helps in transfer of Proton i.e. H^+ from anode compartment to the cathode compartment. This PEM is cationic specific hence proton gets easily transfer. We used salt bridge as PEM. i.e. U shaped glass tube.Both jars are connected by a salt bridge.

Procedure followed for MFC

In anode compartment we used 900 ml of waste water and 100 ml of Inoculum of *Enterobacter aerogenes* i.e. 10% of total volume [Inoculum was prepared in Nutrient broth and incubated at 30^oC for 48 hrs. for setting the maximum growth]

In Cathode compartment 1000 ml of 0.1 N Potassium ferricyanide was taken as an electron acceptor. Both compartments having graphite electrode are connected by wires externally.

RESULTS AND DISCUSSION

Chemical Analysis

Table 1. COD of waste water before and after treatment.

Substrate	COD (mg/lit) before treatment	COD (mg/lit) after treatment
Dairy waste water	4500	720

Chemical analysis of dairy waste water was studied with the help of COD test **Table 1.** After the treatment of Dairy waste water, we observed near about 84% reduction in COD,

……

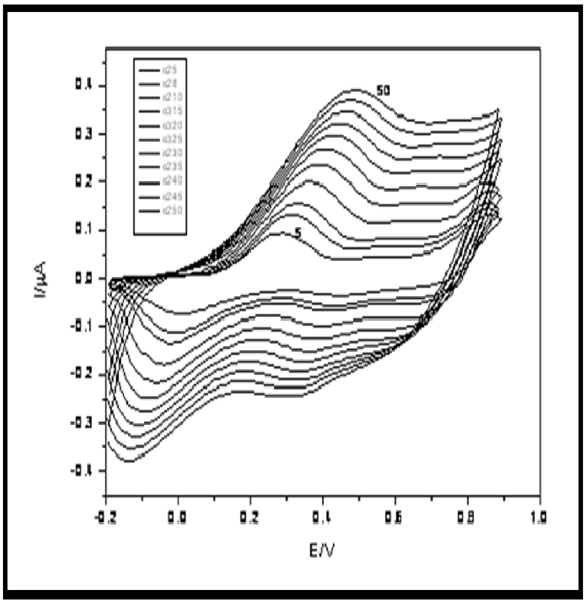


Fig. 2. Cyclic voltammetric scans recorded during polymerization. Scan number indicated in the figure

Two chamber MFC was used to enrich electrochemically active microbes using activated sludge as inoculum and dairy waste as fuel.The anode modifications used in this work were based on enhancement of active surface area, electrical conductivity without use of any catalysts.

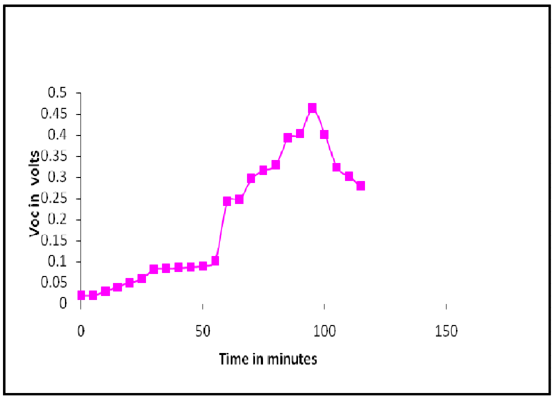


Fig. 3. Variation of open circuit voltage with time for Dairy waste based MFC with uncoated graphite electrode.

This was achieved by depositing PANI on the graphite electrode. The modified graphite materials were characterized by SEM.

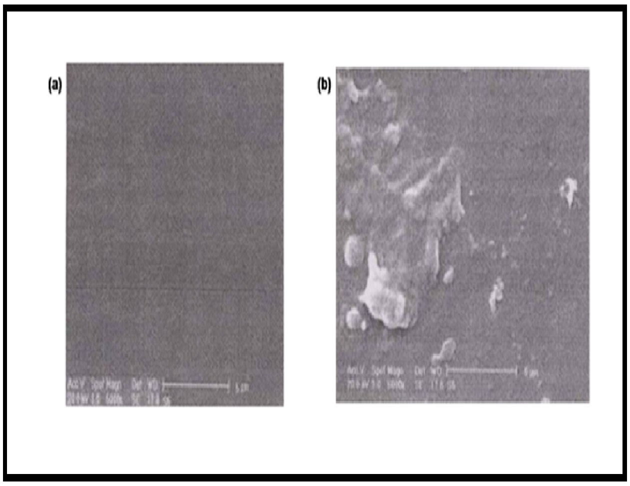


Fig . 4. 1 SEM images of graphite electrode a) before use b) after use

The fuel cell voltage verses time plots demonstrates that the modified anode materials have clear influence over the system performance .When compared with unmodified graphite electrode. This behavior may be duo to enhancement in electrical conductivity. The low voltage o.48 V as shown in figure 5. 7 was observed in the two chamber MFC with unmodified graphite electrode as the anode material . The best performance of MFC with the voltage 1.02 V as shown in fig. 5. 9 was observed with the modified graphite electrode suggesting that the increase in performance was achieved by modifying the graphite anode with PANI showed good behavior which indicates that the PANI is also effective to increase the electrical conductivity.

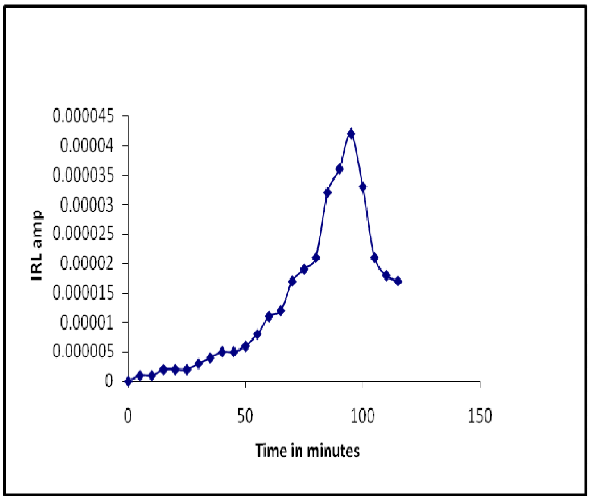


Fig.5. Variation of current with time for dairy waste based MFC with uncoated graphite electrode

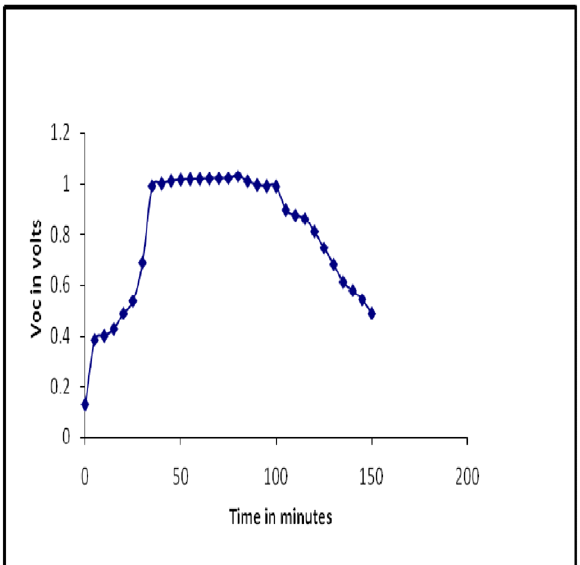


Fig. 6. Variation of open circuit voltage with time for Dairy waste based MFC with PANI coated graphite electrode.

CONCLUSIONS

Dairy waste water is used for electricity generation by using *Enterobacter aerogenes* NCIM 2340. Dairy waste water was more efficient in the generation of electricity. After the treatment of Dairy waste water, we observed near about 84% reduction in COD. The best performance of MFC was observed with the modified graphite electrode. The increase in performance was achieved by modifying the graphite anode with PANI which showed good behavior which indicates that the PANI is also effective to increase the electrical conductivity.

REFERENCES

[1] L.T. Angenent , S. Sung , and L. Raskin , *Water Research*. **2002**, 36, 4648.
[2] D.R. Bond and D.R. Lovley, *Applied and Environmental Microbiology*. **2003,** 69, 1548.
[3] K. J. Chae , M. Choi, F. F. Ajayi , W. Park, I. S. Chang and I. S. Kim , *Energy and Fuels*. **2008** ,22,169.
[4] S. Cheng , and B. E. Logan , *Electrochemistry Communications*. **2007,** 9, 492.
[5] S .Cheng , H. Liu and B. E. Logan , *Environ. Sci. Technol*.**2006**,40, 364.
[6] C. Y. Fung, J. lee, S. C In, and H. K Byung, *J. Microbiol Biotechno*. **2006,** 9,16(9) 1481.
[7] Z .Du, H.Li , and T .Gu , *Biotechnology Advances*. **2007**, 25, 464.
[8] Y. Feng , X. Wang, B. E. Logan , and H. Lee , *Appl. Microbiol Biotechnol*, **2008,** 78, 873.
[9] Z .He, H. Shao and L. T. Angenent , *Biosensors and Bioelectronics*. **2007,** 22, 3252.
[10] L..Huang , B. E. Logan, *Appl. Microbiol biotechnol* . **2008**, 349.
[11] J.K. Jang,. *Process Biochemistry*.**2004**, 39 ,1007.
[12] B. H., Kim , I. S. Chang , G. M .Gadd. *Applied Microbiol Biotechnol.* **2007**,76, 485.
[13] J. R., Kim , S. Cheng , S. E. Oh. and B. E. Logan , *Environmental Sci. Technology*. **2007,** 41, 1004.
[14] J. R. Kim , S. H. Jung, J. M Regan, B. E. Logan , *Biosource Technology* .**2007,** 98, 2568.
[15] J. R. Kim., B..Min., B. E Logan ,*Applied Microbial Biotechnol*. **2005**, 68, 23.
[16] H. Liu, S. Cheng , L. Huang, B. E. Logan, *Journal of Power sources*.**2008,**179, 274.
[17] H Liu, R.Ramnarayanan and B.E. Logan, *Environmental Science Technology*. **2004**, 38, 2281.

[18] B. Logan, S. Cheng, V. Watson, and G Estadt, *Environmental Science and Tech.* **2007**, 41, 3341.
[19] B. E. Logan , Cassandro, Murano, S Keith ,N. D. Gray , I. M. Head , *Water Research*.**2005,**39,942.
[20] B.E. Logan , *Environmental Science Technology*. **2004**,38, 160.
[21] H .Moon, I. S. Chang , B. H. Kim , *Biotech* .**2005**,03,027.
[22] J.Niessen, F.Harnisch, M. Rosenbaum, U.Schroder, F.Scholz ,*Electerochemistry Communications* .**2006**, 8, 869.
[23] J Niessen, U. Schroder, F.Harnisch and Scholz, *Letters in Applied Microbiology*. **2005**, 41, 286.
[24] J. Niessen, U. Schroder , F. Scholz, *Electrochemistry Communications*, **2004,** 6,955.
[25] S. E. Oh , B. E. Logan , *Appl. Microbiol Biotechnol*. **2006** ,70, 162.
[26] K. Rabaey, P. Clauwaert, E. Peter and W. Verstraete , *Environ Sci Technol*. **2005**, 39, 8077.
[27] K. Rabaey , W. Verstraete , *Trends in Biotechnology*. **2005 ,** 23, 6.
[28] K. Rabaey , N. Boon , S. D. Siciliano , M. Verhaege , and W. Verstarte , *Applied and Environmental Microbiology* . **2004**, 5373.
[29] F. Rezael, T. L.Richard , R. A. Brennan , and B. E. Logan, *Environmental sciences Technology*. **2007**, 41, 4053.
[30] M. A, Rodrigo, P.Canizares , J. Lobato , R. Paz , C. Saez, J.J. Linares, *Power Sources*. **2007**, 01,054.
[31] A. Wheatley. A.R. Burkin (ed) *Critical reports on applied chemistry, Elsevier, London* **1990**,31.
[32] E. H. Yu , S. Cheng , K. Scott , B. Logan, *Journal of Power sources*. **2007**,17,275.
[33] Y. Zuo , S.Cheng , D..Call. and B. E, Logan, *Environ. Sci.Technol*, **2007,** 41, 3347.