Review on Carbon Electrodes in Microbial Fuel Cell

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Abstract:*Microbial fuel cell(MFC) is a promising technology in conversion of waste to energy and also providing green environment.In this paper performance of various carbon electrodes in MFC is categorised based on electricity generated working on MFC in various condition. As a new type of electrodes used in MFC which create changes in conductivity and bacterial strains involved in electron transfer, varying its area of contact and material used.*

Key Words: Microbial fuel cell, Electrodes, Waste water treatment

1. Introduction

Electricity production and clean environment plays vital role in human life, MFC is a technology which perform both function by employing microbes in a controlled environment. Aconventional MFC consisting of anode and cathode compartments, is separated by using aproton exchange membrane from each other. Many types of wastewaters such assynthetic, domestic and industrial wastewaters have been recently tested (He et al., 2005; Huang et al., 2008; Ahn et al., 2009).Electrode is the key component in deciding the performance and cost of MFC. Electrode design is the greatest challenge in making MFCs a cost-effective and scalable technology (Rabaey et al., 2009). MFC technology is a prospective technology that purifies wastewater and converts its chemical energy into electrical energy using bacteria as catalysts(Logan et al 2006).To reduce the cost of air–cathodes, several highly specific materials, such as activated carbon, that do not require a catalyst have been developed and reported (Deng et al., 2010; Zhang et al., 2009). For monitoring environmental conditions of remote places, sustainable power generators are necessary to power sensors and telemetry systems because replacing batteries there can be costly and time-consuming in many situations. A sediment microbial fuel cell (SMFC) can be a feasible solution for this purpose (Sokhee P. Jung et al., 2013).

2. Electrodes

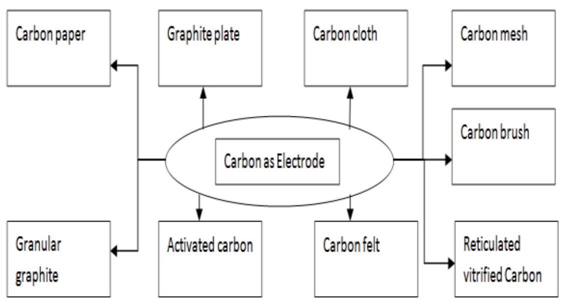
Electrode are the conducting material which perform in transfer of electron from anode chamber to cathode chamber causing useful flow of electron. According to surface area and type of material performance of electrodes varies.The chitin supplement increased maximum power densities by 121% in the magnesium anodes and 164% in the graphite anodes on average (Sokhee P. Jung et al., 2013)

2.1. Carbon Electrodes

Electrode selection plays important role in commercialization of MFC, carbon is one of a trusted material where it can be used as electrode effectively which is available in numerous forms of structure and surface area suitable in MFC. Carbon can be used in any type of MFC because of its flexibility in its size and shape. Cost of carbon electrode is significantly cheaper for commercialisation. According to analytical electrochemistry Basic concepts in research gate[2] Carbon electrodes allow scans to more negative potentials than platinum or gold, as well as good anodic potential windows. The most common form of carbon electrode is glassy carbon, which is relatively expensive and difficult to machine. Carbon paste electrodes are also useful in many applications. These electrodes are made from a paste of finely granulated carbon mixed with an oil substrate like Nujol. The paste is then packed into a cavity in an inert electrode body. Carbon paste electrodes have the disadvantage of being prone to mechanical damage during use.

Material	Advantages	Limitations
Carbon	Many types and configurations quality varies greatly.	Good cathodic potential range hard to shape.

Figure 1. carbon electrodes.



2.2.Electrodes as Anode

There are many material can be used as anode in MFC depending upon surface area these electrode cause flow of electron. Usually carbon material plays major role as electrodes in most of MFC for its characteristics and cost of material. Carbon based electrodes are popular among fabrication of MFC. Table 1 shows carbon Electrode used , MFC type, size of electrode used in a system employing bacterial source and power output for corresponding combination.[1]

Table 1.Carbon anode electrode, MFC type, bacterial source and power output.

Electrode material	Size	Bacterial source	MFC Type	Power output	References
Carbon brush	4cm by 3cm dia	Pre accumulated bacteria from active MFC	Cube air cathode	$2400mW/m^2$	Logan et al.(2007)
Graphite plate	$155cm^2$	Shewanellaoneidenis(MR-1)	Two chamber air cathode	$1410mW/m^2$	Dewan et al.(2008)
Activated carbon cloth	$1.5cm^2$	D.desulfuricans strain	Single chamber air cathode	$0.51mW/m^2$	Zhao et al.(2008)
Carbon Mesh	$7cm^2$	Pre accumulated bacteria from active MFC	Single chamber cube air cathode	$893mW/m^2$	Wang et al.(2009)

2.3. Electrodes as cathode

The performance of MFCs is currently limited by the cathode, and this problem is projected to remain for some time (Logan,2009). Design structure of cathode and selection of material plays major role in commercialisation of MFC. In selection of cathode material which has possible reductionof cost due to its flexibility in using low cost material but when including cost of catalyst(optional) may lead cathode electrode cost more. Catalyst used on cathode electrode which improves performance of MFC. Table 2 shows carbon Electrode used, MFC type, size of electrode used in a system with catalyst and power output for corresponding combination [1].

Table 2. Carbon cathode electrode, MFC type, catalyst and power output.

Electrode material	Size	Catalyst	MFC Type	Power output	References
Carbon clothnafion binder	$7cm^2$	Pt	single chamber cube Air-cathode	$480mW/m^2$	Cheng et al.(2006)
Carbon fiber felt	$36cm^2$	-	Cylindrical two chamber Aqueous air-cathode without catalyst	$315mW/m^2$	Deng et al.(2010)
Carbon cloth PTFE binder	$7cm^2$	Pt	single chamber cube Air-cathode	$360mW/m^2$	Cheng et al.(2006)
Graphite coating on ultrafiltration(UF) membrane	$54cm^2$	CoTMPP	Tubular Single chamber	18W/m2	Zuo et al.(2007)

3.Conclusion

From this paper usage of carbon electrode effectively in various type of MFC is discussed also reduction of cost on electrode by replacing with low cost material without compromising MFC performance and type of MFC used in power generation and effective design aspects in MFC for maximum power output with less manufacturing difficulties are discussed. Dewan et al. found that power densities scale with the logarithm of the projected surface area. (Logan et al.) showed that increasing the overall surface area by employing a graphite electrode brush increased current density by ~2.5 times compared to a carbon cloth anode. At the same time however, Dewan et al. found that current densities for electrodes with a larger surface area cannot always be directly extrapolated using the current densities generated by smaller electrodes.

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BIOGRAPHIES

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