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Effect of oxygen gradient on the organic degradation and power performance of single sediment microbial fuel cells

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Abstract

Microbial fuel cells (MFCs) have been extensively noted nowadays because of their unique dual-function of power generation and enhancement of wastewater treatment performance. But facing their practical use with wastewater treatment in the future, reducing the cost of treatment and requirement for oxygen during the treatment process, while also enhancing their power performance, makes them worthy of study. Therefore, a physical technique of using an interface layer with four kinds of porous sizes embedded in the middle of the MFCs would be utilized in this study. Results show that the performance of MFCs in the case of using an interface layer would be better than in a case of without one regardless of the porous size of the interface material. The role of the interface layer will give a positive and significant effect on the performance of MFCs. Generally speaking, when a smaller pore size of interface was utilized, the better the performance of power and COD degradation in MFCs achieved. A maximum power density of 0.032 mW/m^2 and COD degradation of 47.3% were obtained in the case of an interface porous size of 0.28 μm. The MFC findings in this study will be useful to the practical improvement of wastewater treatment plants in the future

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1. Introduction

Faced with various types of serious pollution as a result of such a massive human population, this issue urgently needs to be resolved [1] because it severely attacks our living conditions. Nowadays, more attention has been paid to the related technology of MFCs and they have been studied because of their dual function of dealing with wastewater and power generation [2]. Commonly, electrons produced in MFCs undertaking a series of bio-chemical reactions are driven by the potential difference between the cathode and anode, finally reaching the electrode of the cathode by way of passing through the external circuit within a reduction reaction while supporting the oxygen requirement. Therefore, how to strengthen the aerobic conditions in the cathode region and also promote the anaerobic conditions at the part of the anode in single type MFCs (i.e., anode and cathode coexist in MFCs) remains an important issue in MFCs [3].

As for the fact that facultative anaerobic bacteria [4-6] requires an anaerobic environment, keeping oxygen in the region of the cathode and preventing it from attacking those anaerobic bacteria in the anode part, these conditions would be required in single MFCs for strengthening the performance of power generation and degradation [7-11]. Here, some studied reports related to separation membranes such as an ultrafiltration membrane [12], osmotic membrane [13], cation exchange membrane [14] and J-Cloth [15] summarized in Table 1 were utilized for preventing oxygen diffusion from the cathode to anode [12-14].

Table 1 shows that studies executed would attempt to prevent oxygen diffusion by way of setting up different separation membranes, but they cannot clearly define the quantitative indicators of the interface layer for the oxygen diffusion effect. Therefore, a series of cases would be studied and executed for understanding the effect of an oxygen gradient on the organic degradation and power performance in single MFCs.

Table 1 Interface layer versus power performance of system

Method	DO	Power Density	COD	Ref.
Ultrafiltration Membrane	NA	36 mW/m^2	NA	[12]
Permeable Membrane	2.5	28 $\mu W/cm^2$	NA	[13]
Anion Exchange Membranes	NA	125.4 mW/m^2	NA	[14]
J-Cloth	NA	627 W/m^3	NA	[15]

2. Experimental material and Methods