Effect of anode aeration on the performance and microbial community of an air–cathode microbial fuel cell

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Abstract

An air–cathode microbial fuel cell (MFC), previously enriched under anode anaerobic conditions, was exposed to air intermittently and continuously, to investigate the effects of anode aeration on power generation and microbial community. Intermittent aeration had little influence on power generation except reduction in coulombic efficiency (CE). During continuous anode aeration lasting 420 h, a considerable amount of electricity with a voltage of 0.35–0.41 V (1000 Ω external resistor) was produced within a wide range of dissolved oxygen concentrations (0.1–4.0 mg/L). Anode aeration influenced maximum voltage output less, but reduced CE significantly. The MFC reclaimed previous power generation ability soon after aeration stopped. Aeration caused a decline in anode microbial diversity compared to the anaerobic control with Burkholderia sp., Bacteroidetes sp., Simplicispira sp., Rhodocyclaceae sp., and Microbacterium sp. being the dominant members. The air–cathode MFC enriched under anaerobic conditions showed a good resistance to oxygen and demonstrated the potential to generate electricity under anoxic and aerobic conditions.

1. Introduction

Microbial fuel cell (MFC) is a bio-electrochemical system operated with exoelectrogenic microbes that possess the ability to donate electrons to the anode of the fuel cell in order to produce electricity. Exoelectrogenic bacteria are capable of transferring electrons outside their cells through direct contact or using soluble electron shuttles [1]. Known exoelectrogens primarily fall into several functional groups based on types of respiration, including obligate anaerobic, facultative and aerobic bacteria. Different types of exoelectrogens may have different response to the presence of oxygen. For example, Geobacteraceae, which have been found to be associated with power generation in many microbial fuel cells, are obligate anaerobes and very sensitive to the presence of oxygen, and a slight air-exposure will halt cell respiration [2]. Shewanella, another well known exoelectrogens, are facultative anaerobes and metal reducing bacteria, which can produce power under both anaerobic and aerobic conditions [3,4]. For example, Biffinger et al. [3] compared the performance a mini MFC fed with glucose and inoculated with a pure strain Shewanella under aerobic and strictly anaerobic conditions, and found that more power density (270 ± 10 W/m³) was obtained when the anode chamber was exposed oxygen compared to the anaerobic control (≤ 100 W/m³). In addition, some exoelectrogens are aerobic facultative bacteria, such as Pseudomonas sp. and Burkholderia sp. [5,6], which can use both oxygen and anode electrode as electron acceptors.

Although various exoelectrogeneic bacteria with different respiration types have been found, most of reported MFCs utilized anaerobic bacteria as the major population in the anode chamber to produce power. Therefore, proton exchange membranes (PEMs) are generally used to separate the anode and cathode chambers in order to prevent oxygen diffusion from the aerobic cathode. In fact, a small amount of oxygen can penetrate to the anode chamber...