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Double-chamber microbial fuel cells started up under room and low temperatures

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ABSTRACT

This study examined the performances of two double-chamber microbial fuel cells (MFCs) at 25 °C and 15 °C. After successful startup, the cell temperature of MFC A was decreased from 25 to 15 °C, yielding a sudden breakdown of the entire system. Conversely, the MFC B, started up at 15 °C, delivering higher power density at 25 °C than MFC A at the same temperature. The electrochemical analysis revealed that the MFC B had lower anodic resistance than MFC A. Additionally, a negative temperature dependence of the polarization resistances of the anodic biofilm was noted, a novel phenomenon only reported in this double-chambered study. Microbial analysis showed that the psychrophilic bacteria were enriched in anodic biofilms of MFC B, which likely contributed to the robust cell performance of the present double-chambered MFCs.

1. Introduction

The anodic biofilm in a microbial fuel cell (MFC) is oxidizing substrates to generate electricity [1]. The anodic resistance contributes to the overall cell resistance in MFC operation [2–5]. Torres et al. [6] noted that the anode potential affects the microbial community in anodic biofilms of an MFC. The kinetics of the anode-respiring bacteria (ARB) determines the performances of certain MFCs [7–10]. After appropriate reactor design and integration, the MFC was proposed to be applied in large-scale wastewater and waste treatment [11–15].

The temperatures of MFCs were widely studied at or above 20 °C. Jadhav and Ghangrekar [16] reported enhanced MFC performance at low rather than at high temperatures. In a tested MFC, the power production was decreased with decreasing operational temperature [17]. Conversely, Liu et al. [18] noted that the single-chambered MFCs started up at 15 °C are more stable in operation than those at 25 °C. This observation has not been checked by other types of MFCs.

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To operating MFC at low temperatures has significant practice needs. On the other hand, the MFC that could be operated at room and low temperatures is desired. This study is a continuation of Liu et al. [18] to start up double-chambered MFCs at low and room temperatures. We demonstrated in this work that to start up an MFC at low temperature is a preferred option than at room temperature, which is true in single-chambered MFC in [18] and in double-chambered MFC studied here.

2. Materials and methods

2.1. Inoculum and MFC

Two double-chambered MFC (A and B) were used. The geometry of the reactor is (length: 10.5 cm; width: 7 cm; height: 7 cm). The volumes of the anode and cathode compartment were both 70 ml. The anode compartment was purged with nitrogen before the experiment. Between compartments Ultrex proton-exchange membrane (Membranes International, Inc, Glen Rock, NJ) was positioned. The membrane was incubated in 2% NaCl at 45 °C for 18 h prior to use. The anode and cathode were made of carbon cloth of surface area of 14 cm^2.

The anaerobic sludge collected from Harbin Wenchang Wastewater Treatment Plant was the inoculum. The MFCs were fed in batch mode with anode solution (NaAc 2.0 g l^{-1}, NH_4Cl 0.62 g l^{-1}, KCl 0.26 g l^{-1}, NaH_2PO_4 4.9 g l^{-1}, Na_2HPO_4 9.15 g l^{-1}), mineral solution 12.5 ml, and Wolfe's vitamin solution 5 ml, with pH being adjusted to 7.0. The MFCs were fed with cathode solution PBS and 16.46 g l^{-1} $K_3[Fe(CN)_6]$.

Both electrodes were hung from titanium wires and were connected through a 1 kΩ resistor. Reference Ag/AgCl electrode (type 217, XianRen Industries Co., Shanghai, China) was installed into the anodic chamber for conducting electrochemical measurements. The MFC A was first operated at 25 °C for 30 d, then the reactor temperature was dropped to 15 °C for another 30 d. Conversely, the reactor B was first operated at 15 °C for 32 d, then the reactor temperature was increased to 25 °C for another 32 d.

2.2. Electrochemical analysis

The MFC were operated for at least three full cycles with stable cell performance before electrochemical analysis was

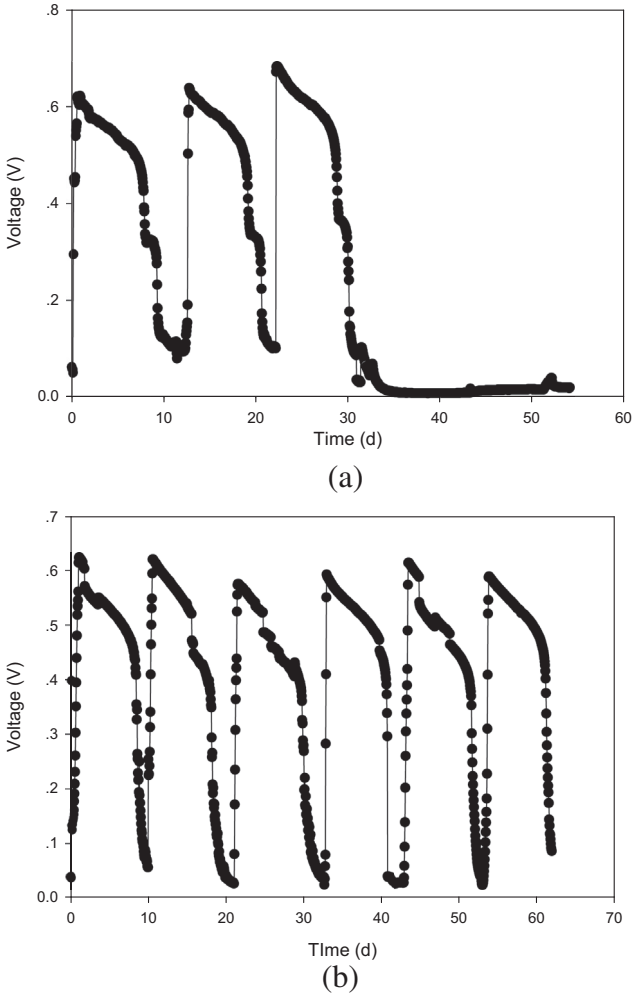

Fig. 1 – Cell performances at different reactor temperatures. (a) MFC A: 25 °C during 1–36 d, 15 °C during 37–55 d. (b) MFC B: 15 °C during 1–25 d, 25 °C during 26–43 d.

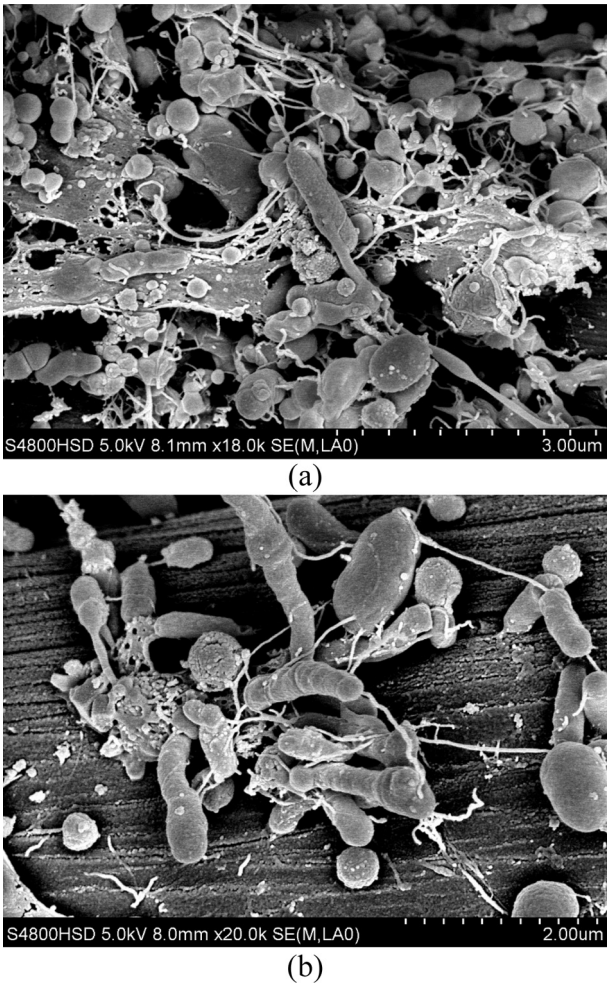

Fig. 2 – SEM photographs for anodic biofilms at the end of tests. (a) MFC A, (b) MFC B.