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PROLONGED STABILITY OF AIR-CATHODE MICROBIAL FUEL CELL PERFORMANCE BY INHIBITING AEROBIC MICROBIAL GROWTH USING PLATINUM AND CARBON NANOTUBE (PT-CNT) NANOPARTICLES AS A CATHODE CATALYST

M. Amirul Islam[1], C. Wai Woon[1], E. Baranitharan[1], C. Kui Cheng[1], A. Yousuf[2] and M. R. Khan*[1]

[1] Faculty of Chemical Engineering & Natural Resources, [2] Faculty of Engineering Technology, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia.
(amirul.geb@gmail.com, cheewaiwoon@gmail.com, baranitharanibt@gmail.com, chinkui@ump.edu.my, ayousufcep@yahoo.com, mrkhancep@yahoo.com)

ABSTRACT

The inescapable growth of heterotrophic aerobic bacteria on the surface of air cathodes is an important factor causing oxygen depletion and substrate loss thus reduce the performance stability of air cathode single-chamber microbial fuel cells (MFCs). In this study, the possible use of platinum and carbon nanotube (Pt-CNT) nanoparticles as an antimicrobial agents as well as cathode catalyst for air-cathode MFCs was examined. The biomass content on carbon air-cathodes (CACs) was substantially decreased by 38.2% with Pt-CNT treatment after 26 days of MFCs operation. As a result, the oxygen reduction catalytic performance of the Pt-CNT treated CACs was much stable whereas the fast performance decline of the untreated cathode. Consequently, a quite stable electricity production was obtained for the MFCs with the Pt-CNT treated CACs, alternatively with a 22.5% decrease in maximum power density of the MFCs observed with the untreated cathode. Based on these results, it can be concluded that (1) the growth of oxygen-consuming heterotrophic microbes could be inhibited by Pt-CNT, (2) Pt-CNT could be applied as a cathode catalyst for oxygen reduction, thus (4) the MFC with the Pt-CNT -coated cathode led to the enhenced stable current generation.

Key words: Air-cathode microbial fuel cell, Platinum nanoparticles, Oxygen reduction reaction, Bacterial inhibition

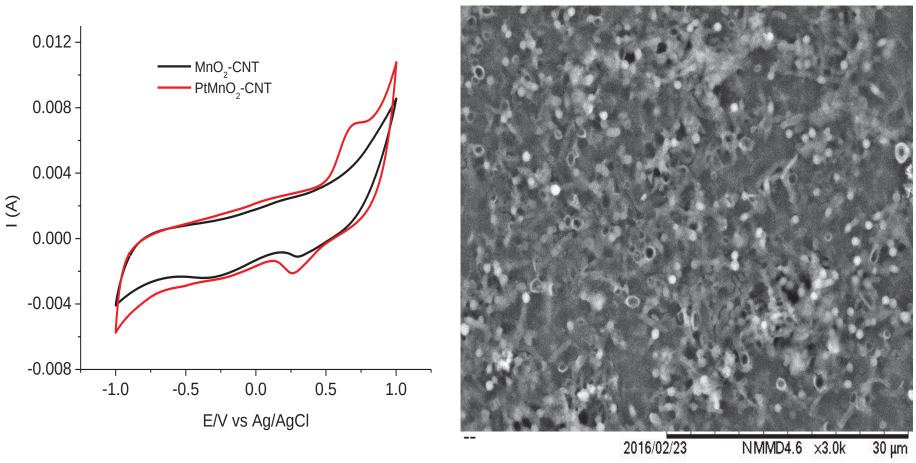
INTRODUCTION

Several types of MFCs have been developed, including two-chamber, single-chamber, upflow membrane-less and tubular designs[1]. Among the different types of MFCs that have been developed, the air cathode MFC is the most likely configuration to be scaled up for wastewater treatment due to its high power output, simple structure, and relatively low cost[2]. Although several conveniences have been reported for the air-cathode MFC but some severe cruxes such as sluggish reaction rate in cathode, cathode flooding via anodic solution and aerobic microbial growth thus leading to mass transfer losses resulting low power output of air-cathode MFCs[3].

The inevitable growth of aerobic bacteria on the surface of air cathodes is a crucial factor reducing the performance stability as well as increases mass transfer loss of air cathode single-chamber MFCs[4]. A thick biofilm on cathode layer may adversely influence the cathode performance through several mechanisms such as creating diffusion barrier to the transfer of H^+ and charged ionic species to the catalyst sites[5], (2) it can severely block the OH^- transport, resulting in a significant OH^- accumulation in the cathode microenvironment and thus a reduced cathode potential[6] (3) the aerobic bacteria may consume a portion of the available oxygen at the catalytic sites and thus reduce the oxygen reduction reaction (ORR) kinetics [6]. As a result of the suppressed cathode performance, an increased internal resistance coupled with a decreased electricity (power) generation of MFCs after long-term operation was observed in many studies. A 10%-30% increase in power density has been found after removing the thick biofilm on air cathodes of single chamber MFCs[5].

In this study, Pt, was incorporated into the catalyst layer of activated carbon air cathodes (ACACs) to inhibit the cathodic microbial growth which has recently been revealed the appropriate antibacterial activity against both gram-negative and positive bacteria. Moreover, power generation, electrochemical impedance and cyclic voltammetry were measured to evaluate the electrochemical performance of Pt incorporated MnO_2-CNT catalyst.

MAIN RESULTS



A B

Figure 1. (1A) Cyclic voltammogram observation of MnO_2-CNT and $PtMnO_2$-CNT after 9 days of operation, (1B) Scanning electron microscopy (SEM) visualization of aerobic bacterial cell wall disruption by Pt nanoparticles.

CONCLUSION

In this study, we have proposed, a anitimicrobial nanoparticles (Pt) incorporationg catalyst

($PtMnO_2$-CNT) to inhibit the microbial growth on air faced cathode electrodes. Compared to the MnO_2-CNT, $PtMnO_2$-CNT catalyst significantly reduced the cathodic biomass by 38.2%, thus enhanced the stability of performance by increasing ORR activity in air-cathode MFC. However, further study is needed to elucidate, the microbial inhibition efficiency and to optimize the combination mode between the antimicrobial nanoparticles and catalyst layer.

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