Medium-chain-length poly-3-hydroxyalkanoates-carbon nanotubes composite anode enhances the performance of microbial fuel cell

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Received: 29 November 2016 / Accepted: 1 March 2017
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Abstract Insufficient power generation from a microbial fuel cell (MFC) hampers its progress towards utility-scale development. Electrode modification with biopolymeric materials could potentially address this issue. In this study, medium-chain-length poly-3-hydroxyalkanoates (PHA)/carbon nanotubes (C) composite (CPHA) was successfully applied to modify the surface of carbon cloth (CC) anode in MFC. Characterization of the functional groups on the anodic surface and its morphology was carried out. The CC-CPHA composite anode recorded maximum power density of 254 mW/m\textsuperscript{2}, which was 15–53% higher than the MFC operated with CC-C (214 mW/m\textsuperscript{2}) and pristine CC (119 mW/m\textsuperscript{2}) as the anode in a double-chambered MFC operated with \textit{Escherichia coli} as the biocatalyst. Electrochemical impedance spectroscopy and cyclic voltammetry showed that power enhancement was attributed to better electron transfer capability by the bacteria for the MFC setup with CC-CPHA anode.

Keywords Microbial fuel cell · Anode modification · Polyhydroxyalkanoates · Carbon nanotube · \textit{Escherichia coli}

Introduction

A continuous increase in the utilization of non-renewable energy source such as fossil fuels has negative implications, especially from the environmental perspectives. The global increase in energy demand, as well as pollutants released from combustion of these energy sources, posed a need to find a cleaner and environmental-friendly alternative [1]. Recent advances in renewable energy research have led to the production of clean and sustainable energy such as bioethanol [2], biohydrogen [3], and bioelectricity [4] etc. Bioelectricity is bioenergy produced from biofuel cell such as microbial fuel cell (MFC). The MFC is a biocatalytic system that has drawn global attention due to its ability to harness electrons produced from metabolic activities of microorganisms in generating electrical current [5]. Typical MFC consists of anode and cathode compartments separated by a proton exchange membrane in a double-chambered setup. Whilst significant literature is available on the power produced in MFC [6], its low power generation remained a major cause of concern hence, limiting its widespread, large-scale applications.

The anode material that acts as an electron sink for the bacteria is a critical component of the MFC. Although the conventional anode material such as carbon cloth (CC), carbon paper, graphite felt are conductive and stable, power density recorded from MFCs utilizing such materials remained low owing to the fact that they lack the ultimate surface area and compatibility required for internal colonization by the microorganism [7]. We have recently reviewed several anode modifications that have been studied to circumvent these limitations [8], which include doping with metal [9], modification with graphene [10],