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Effects of anode materials in electricity generation of microalgal-biophotovoltaic system – part II: Free-floating microalgae in aeration mode

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ABSTRACT

A biophotovoltaic (BPV) system is a developing renewable energy technology that promises carbon-free electricity generation from solar energy, by utilizing photosynthetic exoelectrogenic microorganisms. The electrical power production of BPV devices, on the other hand, is relatively low, and this has become a significant challenge for this new technology. Sufficient supply would require large-scale BPV farms for megawatt applications, which may not be economically viable. A possible solution is to acquire bioelectricity from algae cultivation medium, as it benefits the system in terms of volume. Moreover, it enables combination with an algae pool or floating photobioreactor. One technical concern is that previous studies focused on the absorption of electrons from cultivated biofilm, whereas bioelectricity generation by aerated algae cultivation medium under different anode materials still has research value. Hence, cell performance by well-mixed anodic algae cultivation medium under different anode materials is a crucial decision-making factor of BPV device in aeration mode. In this study, the experiments were repeated three times to compare the performances of various anode-based devices. In the experiments, indium tin oxide (ITO)-coated glass-based BPV device produced a steady power output, comparable to those of graphite- and ITO-coated plastic-based BPV devices. Maximum power densities of 0.659 mW/m^2, 0.437 mW/m^2, and 0.059 mW/m^2, respectively, were obtained in each repeated condition. The findings are expected to contribute to further understanding on the correlation of these parameters, with regards to power generation of the BPV devices.

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1. Introduction

Elevating population growth and rapid urbanization have led to a rising demand for new energy resources. Global Energy and CO2 Status Report 2018 reported that annual global energy consumption had increased by 2.3% because of continued economic growth of 3.7% in 2018 [1]. International Energy Outlook 2019 estimated that there will be more than 50% increase in global energy consumption from 2018 to 2050 due to the continuous development of non-OECD (Organization for Economic Co-operation and Development) countries [2]. According to BP Statistical Review of World Energy 2021, the current reserves-to-production ratios of natural gas and crude oil reserves in 2020 would account for another 48.8 years and 50 years of current production, respectively [3].

BPV system is an emerging renewable energy technology that utilizes natural photosynthesis of exoelectrogenic microorganisms for bioelectricity generation. During photosynthesis, exoelectrogens release electrons extracellularly to insoluble electron acceptors, such as electrode of the power plant [4]. BPV is one type

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