Received: 30 January 2019 | Revised: 5 July 2019 | Accepted: 11 July 2019

DOI: 10.1002/ese3.414

RESEARCH ARTICLE

Energy Science & Engineering Open Access

Effect of different irradiance levels on bioelectricity generation from algal biophotovoltaic (BPV) devices

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Funding information
Newton Prize 2017, Grant/Award Number: IF008-2018; IOES UMCoE RU, Grant/Award Number: RU009B-2018; HICoE MOHE Phase 2, Grant/Award Number: IOES-2019-2021; UM Algae, Grant/Award Number: GA003-2012

Abstract

Rapid population and economic growth in the world have accelerated the search for new sustainable and environment-friendly energy sources. Power-producing systems generally add to the carbon load in the environment, contributing to global climate change. In photosynthesis, energy from light splits water molecules into oxygen, protons, and electrons. Algal biophotovoltaic (BPV) platforms were developed to harvest these electrons to generate bioelectricity through algal photosynthesis. Irradiance is one of the most important parameters that determine power output efficiency from algal BPV devices. In this study, the effective range of irradiance levels for power generation from algal BPV devices comprising of suspension and alginate-immobilized *Chlorella* cultures on ITO anodes was determined. Immobilized cultures were prepared by entrapping the algal cells in 2% sodium alginate solution. The algal BPV devices were illuminated by four different irradiance levels (30, 90, 150, and 210 µmol photons m^{-2} s^{-1}). The maximum power density of 0.456 mW m^{-2} was generated from the prototype algal fuel cell at the irradiance level of 150 µmol photons m^{-2} s^{-1}. At 210 µmol photons m^{-2} s^{-1}, low power density was produced due to photoinhibition as indicated by F_v/F_m values generated through PAM fluorometry. In terms of carbon fixation rate, the highest value was recorded in immobilized culture at 217.11 mg CO_2 L^{-1} d^{-1}. The algal biophotovoltaic device is multifunctional and can provide sustainable energy with simultaneous carbon dioxide removal.

KEYWORDS
algal biophotovoltaic device, bioelectricity, biotechnology, carbon fixation, irradiance, microalgae

1 | INTRODUCTION

The significant increase in world energy consumption along with the expanding human population is leading to excessive carbon emissions to the atmosphere and climate change. Various clean energy alternatives including algal biophotovoltaic (BPV) devices have been proposed to tackle the carbon emission problem. Hammarström[1] stated that 0.02% of solar energy that arrives on the earth's surface would produce sufficient energy to satisfy the world's energy demand, if the device has 15%-20% energy conversion efficiency. A BPV device contains photosynthetic microorganisms that absorb and convert solar energy into chemical energy with minimal carbon footprint.[2] BPV platforms consisting of live