Journal of Applied Phycology
https://doi.org/10.1007/s10811-018-1515-1

8TH ASIAN PACIFIC PHYCOLOGICAL FORUM

Algal biophotovoltaic (BPV) device for generation of bioelectricity using *Synechococcus elongatus* (Cyanophyta)

Fong-Lee Ng[1] · Siew-Moi Phang[1,2] · Vengadesh Periasamy[3] · John Beardall[4] · Kamran Yunus[5] · Adrian C. Fisher[5]

Received: 25 January 2018 / Revised and accepted: 14 May 2018

Abstract
The exploitation of renewable energy sources for delivering carbon neutral or carbon negative solutions has become challenging in the current era because conventional fuel sources are of finite origins. Algae are being used in the development of biophotovoltaic (BPV) platforms which are used to harvest solar energy for bioelectricity generation. Fast-growing algae have a high potential for converting CO_2 from the atmosphere into biomass and valuable products. In photosynthesis light-driven splitting of water occurs, releasing a pair of electrons and generating O_2. The electrons can be harvested and converted to bioelectricity. In this study, algal biofilms of a tropical cyanobacterial strain *Synechococcus elongatus* (UMACC 105) were formed on two types of electrodes, indium tin oxide (ITO) and reduced graphene oxide (rGO), and investigated for use in the algal biophotovoltaic (BPV) device. The highest maximum power density was registered in the rGO-based BPV device (0.538 ± 0.014 mW m^{-2}). This illustrates the potential of this local algal strain for use in BPV devices to generate bioelectricity in both the light and dark conditions.

Keywords Algal biophotovoltaic (BPV) device · Bioelectricity · Cyanophyta

Introduction

Sunlight is the most abundant and sustainable source of energy available to humanity. Annual solar energy production is approximately 120,000 TW and estimated to be about 20,000 times more than the present annual energy consumption of the world (Blankenship et al. 2011). There is a huge drive to develop low carbon technologies and how to capture and store radiant energy for societal use is one of the greatest challenges of our age. The total amount of biomass produced by photosynthesis is equivalent to 4×10^{21} J of energy, approximately 10 times the total annual global energy consumption (Helmut 2005). Algae are known to be one of the most photosynthetically efficient organisms, harnessing solar energy into the production of a diverse range of products such as biopharmaceuticals and bioenergy (Lim et al. 2010).

Cyanobacteria (Cyanophyta) or blue green algae are a distinct group of photosynthetic organisms. They are the only prokaryotes with oxygenic photosynthesis. Cyanobacteria are prokaryotes and as such the energy-transducing membranes are not located in mitochondria or chloroplasts as in higher plants. They are contained in a densely packed membrane system (thylakoids) in the cytoplasm (Binder 1982). Cyanobacteria generally harness 0.2 to 0.3% of the solar energy. The amount of energy that passes through the cyanobacteria exceeds by more than 25 times the energy demand of human populations and an estimated 1000 times the energy produced by all the nuclear plants on Earth. On a global scale, Cyanobacteria fix an estimated 25 Gigatonnes of carbon from CO_2 per year into energy-dense biomass (Pisciotta et al. 2010).

✉ Fong-Lee Ng
fonglee_ng@yahoo.com

✉ Siew-Moi Phang
phang@um.edu.my

[1] Institute of Ocean and Earth Sciences (IOES), University of Malaya, 50603 Kuala Lumpur, Malaysia

[2] Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia

[3] Low Dimensional Materials Research Centre (LDMRC), Department of Physics, University of Malaya, 50603 Kuala Lumpur, Malaysia

[4] School of Biological Sciences, Monash University, Clayton, Victoria 3800, Australia

[5] Department of Chemical Engineering and Biotechnology, University of Cambridge, Philipa Fawcett Drive, Cambridge CB3 0AS, UK

Published online: 30 May 2018