Effect of Different Irradiance Levels on Bioelectricity Generation from Algal Biophotovoltaic (BPV) Devices

C H Thong[1], S M Phang[1], F L Ng[1], V Periasamy[2], A Gonzalez-Aravena[3], K Yunus[3], A C Fisher[3]

[1]Institute of Ocean and Earth Sciences, University of Malaya
[2]Low Dimensional Materials Research Centre, Department of Physics, University of Malaya
[3]Department of Chemical Engineering and Biotechnology, University of Cambridge

Email(s): thongch2393@gmail.com, phang@um.edu.my, fonglee_ng@yahoo.com

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 harness solar energy for bioelectricity generation. In photosynthesis, a very small amount of solar energy absorbed is transformed into chemical energy while the rest is wasted as heat and fluorescence. This energy can be harvested through biophotovoltaic (BPV) platforms to generate electrical power. During photosynthesis, algae consume carbon dioxide and release oxygen, while producing biomass. One of the most important parameters that affect photosynthetic performance of algae is light. Overexposure to light causes photodamage of Photosystem II and impedes electron shuttle from the algal cells to the anode of the BPV devices. In the present study, we studied the effect of varying irradiance levels on the efficiency of our BPV platforms. Algal biofilms were grown from suspension and alginate-immobilized Chlorella sp. (UMACC 313) cultures on ITO-coated glass anodes. The BPV devices were illuminated by four different irradiance levels (30, 90, 150 and 210 µmol photons m^{-2} s^{-1}) to investigate the effect of different irradiance levels on the power output of the devices. Our prototype Algal Fuel Cell produced maximum power densities of 0.377 mWm^{-2} from suspension cultures at 90 µmol photons m^{-2} s^{-1} and 0.456 mWm^{-2} from immobilized cultures at 150 µmol photons m^{-2} s^{-1}. The lowest power output from immobilized cultures was recorded at 210 µmol photons m^{-2} s^{-1}, thus suggesting that the algae were already experiencing photo-induced stress and partial photoinhibition had occurred at high irradiance level.

Keywords: Irradiance; Bioelectricity; Algal Biophotovoltaic Devices; Biofilms