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Sustained power output from an algal biophotovoltaic (BPV) platform using selected marine and freshwater microalgae

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Abstract

The global community has begun tackling the grave repercussions of excessive use of fossil fuels by strategizing co-usage of renewable and non-renewable energy sources as major energy providers. Recently, biomass feedstocks including microalgae are gaining recognition as crucial energy providers to cope with the demands of the fast expanding economic and social sectors. Algae, known as one of the most photosynthetically efficient organisms, are amenable to growth on a variety of substrates, and are tolerant towards extreme conditions. The integration of microalgae into photovoltaic platforms is an innovative energy provisioning technique for low-power appliances and circuits. Our algal biophotovoltaic (BPV) platforms have undergone multiple refinements, advancing from an ITO-based anode with biofilm grown on its surface prototype to the current integrated, multi-functional device that produces bioelectricity, bioremediates wastewater and assimilates carbon dioxide (CO_2). This study explores the ability of our algal BPV platforms in sustaining power output as well as their performance after nutrient replenishment. Our BPV prototype devices generated up to 32.83 μW m^{-2} from the freshwater cyanobacterium *Synechococcus elongatus* UMACC 105 and 0.11 μW m^{-2} from the marine alga *Chlorella vulgaris* UMACC 258. Power output was maintained by both freshwater and marine microalgal strains for 50 days, thus demonstrating their high potential as long-term low power generators throughout an extended duration in a minimal stress environment.

Keywords Chlorohyta · Cyanobacteria · Green energy · Bioelectricity · Biophotovoltaic · Microalgae

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Introduction

As fossil fuel reserves begin to run dry from overexploitation, high expectations are placed on renewable energy sources to rivet energy security at a smaller environmental footprint. Fossil fuels are accountable for 29 gigatonnes per year release of CO_2 (Khan et al. 2018) and the figure is expected to continue surging in alignment with the rising global population. Large funds are being poured into the renewable energy market for sourcing and development of renewable energy technologies that generate lower greenhouse gases and pollutants. Most renewable energy sources have minimal negative impacts on the environment but none could truly be tagged as a carbon negative solution until the emergence of algal biophotovoltaic (BPV) platforms that provide energy through photosynthesis.

Microalgae, also known as phytoplankton, are a diverse group of photoautotrophic unicellular organisms (Tang et al. 2020) with a size range of 1–50 μm (Ramos-Romero et al. 2021). Microalgae initiate photosynthesis when light energy

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