Algae Biofilm on Indium Tin Oxide Electrode for Use in Biophotovoltaic Platforms

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**Abstract**

Algae are amongst the most photosynthetically efficient organisms harnessing solar energy for all its metabolic life-supporting activities. The solar energy is transformed into chemical energy in a normally wasteful process. In this study, this excess wasted energy may be directed towards electricity generation in a biophotovoltaic platform. This is a new approach in renewable energy production from algae. As an initial step, algal biofilms are established on indium tin oxide (ITO) anodes. Two microalgae, the unicellular *Chlorella* UMACC 313 and the filamentous *Spirulina* UMACC 159 were used to form biofilm on ITO anodes under three different treatments (T\(^1\): unmodified smooth surface, T\(^2\): modified surface etched with interval of 2.5 mm between lines and T\(^3\): modified surface etched with interval of 1 mm between lines). Results show significantly higher biofilm coverage on the etched anodes compared to the smooth ones. Anodes of T\(^3\) registered the highest biofilm coverage of 99.46% for *Chlorella*. For *Spirulina*, highest biofilm coverage (80.70%) was observed on T\(^2\) anodes. The increase in biofilm coverage successfully resulted in increase of photosynthetic efficiency for both strains. *Spirulina* registered the highest maximum relative electron transport rate at 153.507 µmol electrons m\(^{-2}\)s\(^{-1}\) compared to *Chlorella* (140.796 µmol electrons m\(^{-2}\)s\(^{-1}\)). This was correlated to pigment content. Biofilms established on the ITO anodes and the resulting high rate of photosynthetic efficiency achieved in these experiments are expected to enable electrical energy production from biophotovoltaic platforms.

**INTRODUCTION**

In photosynthesis, charge separation takes place in the electron transport chain with the energy directed for use in biomass production and the rest being wasted. Radiant energy absorbed by chlorophyll can undergo one of three fates: (i) used for photosynthesis (ii) dissipated as heat or (iii) re-emitted as chlorophyll fluorescence [1]. Hence, by measuring the yield of chlorophyll fluorescence, information about efficiency of photochemistry and heat dissipation can be generated using a pulse amplitude modulation (PAM) fluorometer (Diving PAM, Walz, Germany) [2]. In our current work, the capture and utilization of this excess and wasted energy is converted to electricity using a proposed biophotovoltaic (BPV) platform.

Cyanobacteria have been used for hydrogen generation [3] and electricity generation using 2-hydroxy-1,4-naphthoquinone as an electron shuttle between the algae cells and a carbon-cloth anode [4]. A bioreactor with an air cathode and a graphite-felt anode coated by a biofilm of bacteria...