Arduino-Controlled Photobioreactor Algal Microbial Fuel Cell With Conveyor Belt Cathode for Boosted Biofilm Growth and Heavy Metal Removal

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Sources of renewable energy and clean water are threatened due to rising temperatures, which can trigger eutrophication. Biophotovoltaic fuel cells using microalgae and integrated wastewater management can produce renewable electricity. Traditional photobioreactor microbial fuel cells destabilize microalgae biofilm growth, requiring costly catalysts to stabilize the biofilm maturation. Using a conveyor biofilm-based cathode in a photobioreactor microbial fuel cell can remove heavy metals and increase voltage generation. The biocathode conveyor maintains a 70-30 ratio between CO2-rich gaseous phase and aqueous phase consisting of heavy metals and wastewater effluent to boost Chlorella Vulgaris growth. A lab-based photobioreactor was replaced by Arduino sensors, pH and dO2, to grow Chlorella biofilm. Monitored pH levels ensured that heavy metal ion solution was reintroduced into the cathode when pH increased to 7. Dissolved oxygen monitored Chlorella growth, matched with visible biofilm attaching onto carbon cloth. For measuring voltage across the Aquivion E98-15SA proton exchange membrane, a divider circuit of external resistance of 32k and 1.5DC voltage was added to increase resolution to 0.75mV/bit. The Aquivion membrane allowed for hydrogen ions and ammoniacal nitrogen, a byproduct of Bacillus bacteria respiration, to be supplied to Chlorella for photosynthesis. This boosted Chlorella respiration, leading to peak voltage of 135 mVs compared to control MFC peak 87 mVs. Increased biofilm growth allowed for average 85% heavy metal ion removal of Ni2+, Cu2+ and Cd2+. This project demonstrates that a conveyor belt can improve the biocathode such to increase biofilm growth for wastewater management and voltage production.

Awards Won:
Fourth Award of $500