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THE INVESTIGATION OF NEOCHLORIS OLEOABUNDANS BIOMASS AS POTENTIAL SUBSRATE FOR MICROBIAL FUEL CELL

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ABSTRACT

The microalgae-Microbial Fuel Cells (mMFCs) is a promising electricity provider because of microalgae biomass as a substrate in Microbial Fuel Cells (MFCs) is able to generate higher maximum power density compared to other substrates, such as glucose, acetate and etc. Common microalgae biomass species used in mMFCs is high lipid content *Chlorella vulgaris*, which also contains recalcitrant cellulose in their cell wall structure –a hindrance for enzyme attack, thus resisting biodegradation which could affect the performance of MFC. Alternatively, a green algae species which reported has higher lipid content than *Chlorella vulgaris* is *Neochloris oleoabundans*, which has not been yet reported in mMFCs researches. *Neochloris oleoabundans* biomass is demonstrated in this study to generate bioelectricity and evaluate its performance. In order to generate bioelectricity for a long-term operation, a special and high-end MFC reactor configuration is required. Two types of MFC design has been fabricated which are Double Chamber MFC (dMFC) and Single Chamber MFC (sMFC). The difference between the two MFCs are their cathode configuration, where dMFC was using aqueous-aerated cathode design while sMFC was using air-cathode design. Both prototype MFCs were demonstrated with a mixture bioelectrolyte solution of sampled activated sludge as inoculum, Phosphate Buffer Saline (PBS) medium and *Chlorella vulgaris* biomass powder as substrate. As a result, the sMFC produced 18 times higher maximum power density than dMFC. However, the power output still lower than other mMFC researches due to lack some modifications. Thus, a new prototype MFC based on sMFC configuration was modified and improved, such as small size, lightweight, and low internal resistance, is known as sandwich type MFC (pMFC). The special and high-end pMFC design was demonstrated with microalgae biomass species, *Neochloris oleoabundans* about 25.87 ± 2.16 $W.m^{-2}$ in a triplicate and multiple cycles of operation. The Chemical Oxygen Demand (COD) removal percentage was 64.7 ± 16.4 %, while Coulombic Efficiency was 33.9 ± 20.2 %. The internal resistance of pMFCs system was 12.78 kΩ cm^2. Consequently, *Neochloris oleoabundans* biomass did generate bioelectricity greater than the *Chlorella vulgaris* biomass. The analysis through variation of *Neochloris oleoabundans* biomass concentrations of 1.0 g/L, 2.5 g/L and 5.0 g/L showed that the trend of maximum power densities produced was increased as the biomass concentration increased, due to increase of ionic concentration present in the anodic solution. The study of effect of biomass pre-treatment also showed that a completely pulverized microalgal cell walls able to facilitate microbial lipid digestion and improved the bioelectricity generation. Furthermore, the statistical analysis showed its reproducibility results which is the P-value was greater than $\alpha = 0.05$, suggested that there was no significant difference between maximum power densities from variations of different microalgae biomasses over fed-batch cycles of operation of pMFCs. Therefore, the performance of *Neochloris oleoabundans* biomass based pMFCs (NbMs) is a potential alternative source in the practical applications and commercialization of microbial fuel cell technology as alternative energy provider.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Fossil fuels - such as petroleum, natural gas, and coal - is the main energy source used around the world, but its quantities limitation and greenhouse gases emissions remain as a long term issue. The excessive usage of fossil fuels release greenhouse gases, such as CO_x,NO_x, SO_x, and C_xH_y, which cause acid rain and global warming. Since energy demands are exceeding than their production, therefore the solution is simply to find another oil sources. However, it requires time and energy to search and extract new oil sources. Therefore, researchers need to find alternative carbon neutral, sustainable and renewable energy sources other than fossil fuels to increase energy production and reduce global climate change [1]–[3].

Recently, alternative energy sources like solar, wind and hydropower did become a profound prospects in replacing fossil fuel. Another prospect that contributed to the research in finding alternative and sustainable energy but has yet to reach its full potential is biomass products, such as agricultural plants and crops, algae and organic waste. Energy from biomass is another form of captured solar energy, and the benefit is biomass become solar energy storage for concentrated processing and delivery [4]. Algae, escpecially microalgae, is the most considered potential feedstock to produce biomass-based products [5], [6]. Contrary to terrestrial crops and plants, the benefits of microalgae in biomass production are extreme fast growth rates, lesser area required for cultivation, higher efficiencies of photosynthesis, biomass production more continuous, no competition with food production directly, and able to grow by using saline and wastewater [7]. Similarly to terrestrial crops, microalgae can be used for energy and fuel production in various ways, especially anaerobic process to produce gaseous (methane and hydrogen) and liquid (alcohols) forms of biofuels [8].

Biodiesel or renewable diesel is a biofuel that considered as an ideal fuel derivation from microalgae biomass [7]–[9]. To produce biodiesel, microalgae biomass undergo chemical and physical process to produce bio-oil and bio-syngas, at high temperature and zero oxygen condition. Then, the dewatered biomass can go further process such as incineration and lipid extraction. Lipid is extracted from algal cell to