Design of an LED lighting system to increase the biomass’s production rate of Haematococcus pluvialis (HP) algae (LKM1-15)

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I. Introduction

Health is a major concern nowadays. Haematococcus pluvialis (HP) algae are the raw materials used to produce a health beneficial functional food called astaxanthin. Since the demand for HP is increasing, production of the algae needs to be increased to keep up with the demand. Light source is one of the important elements affecting HP algae growth. Different light sources cause HP algae to behave differently.

This project aims to design an LED lighting system to increase the biomass’s production rate of HP algae. Three factors: light wavelength, light intensity and light distribution, are the keys to understanding the relationship between light source and HP algae growth. The ultimate goal of this project is to find the optimal light wavelength, light intensity and light distribution for HP algae growth and hence build an efficient bio-reactor for it.

II. Overall structure of the LED lighting system

III. Methodology

First Stage (Hardware analysis)

An LED lighting tube was analyzed in terms of, for example, the forward voltage and the maximum forward current. From this, a suitable LED driver was chosen.

Second Stage (Experimentation)

These experiments were conducted to find the optimal light wavelength, light intensity, and light distribution for HP algae growth. In each of the experiments,Total Suspended Solids test (TSS test) and Optical Density test (OD test) were performed to measure the dry biomass and concentration of HP algae samples.

Third Stage (Programme Development)

The developed control system includes a micro-controller programme and LCD touch screen. Users are able to change the suitable light intensity of the LEDs. In addition, photon period and temperatures of the bio-reactor surroundings are also displayed on the LCD screen.

IV. Results

Light Wavelength (Graph: TSS test)

A red LED (650nm) produces the highest growth rate, which is 4% higher than that of a white LED. However, the cost of red LED per month: 23.47 HK$; Cost of white LED per month: 39.18 HK$; 57% increase = 6.

Due to commercial reasons, a white LED was chosen because of its highest efficiency.

Light Intensity (Graph: TSS test)

A higher light intensity will enhance the HP algae growth. At the same time, if the light intensity is too high, autotrophs will be formed, and the growth rate will be limited.

100 PAR is the optimal light intensity for HP algae growth, whilst the samples of 150 PAR and 200 PAR starting to form autotrophs and the growth rate is reduced.

Light Distribution (Graph: TSS test)

Reflection and refraction take place while light is being emitted. The inner tube design helps reduce the effect of refraction, but the area for HP algae to absorb light is smaller. The outer tube design without a filter lowers the effect of reflection due to its smaller beam angle. The outer tube design with a filter provides a larger area; therefore more HP algae can absorb light.

V. Conclusion

The objective of this project was to design an LED lighting system and construct a bio-reactor to increase the biomass’s production rate of Haematococcus pluvialis (HP) algae. By adjusting the light intensity and using it in experiments, the results indicate that a white LED with 100 PAR and outer tube design with a filter could provide the best performance.