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Treatment of marine and fresh water microalgae by gliding arc discharge plasma

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The main objective of this research was to investigate the effects of Gliding Arc Discharge (GAD) plasma treatment on the marine microalgae Isochrysis galbana and the freshwater microalgae Chlorella vulgaris. The study also analyzed the influence of the plasma discharge parameters on the physicochemical properties of the treated F/2 algal growth media. Concentrated algal suspensions (10 ml) were affected by GAD plasma discharge in an air-gas mixture at different applied voltages. The GAD device was supplied with a variable amplitude AC voltage generated at 270 kHz via the 1:33 transformer. During experiments the output voltages of the generator varied in the range from 90 V to 250 V. The treatment duration was 300 seconds, with a 30 mm distance between the knife-edge type electrodes and the surface of the algal suspension. The composition of the generated air plasma was analysed by emission spectrometry. The research investigated the influence of plasma discharge parameters on the pH, conductivity, and concentrations of nitrate, nitrite, and hydrogen peroxide in the microalgae growth medium. Furthermore, changes in cell permeability, content of extracted valuable compounds (proteins and carbohydrates), and reproduction rate of microalgae after GAD plasma treatment were studied.

Increasing the output voltage from 50 V to 250 V resulted in a significant increase in life-time of discharge arc from 1.71 ms to 5.21 ms. Emission spectra analysis of the air plasma revealed predominant particles including N2, N2+, N+, NO, and O species. Enhanced plasma ionisation degree was observed with increased output voltage or reduced air flow rate, resulting in increased concentrations of molecular nitrogen ions, atomic oxygen and exited nitrogen molecules. The pH, conductivity, nitrate, nitrite and hydrogen peroxide concentrations in the medium showed a dependence on the plasma discharge conditions. As the output voltage increased, the pH of the F/2 medium decreased, conductivity increased, and radical concentrations increased. Physiological changes in microalgae after plasma treatment were dependent on both the plasma discharge conditions and microalgae species. For C. vulgaris, cell permeabilization occurred at plasma output voltages above 210 V, with significantly lower protein leakage compared to PEF-treated samples. Conversely, the marine microalgae I. galbana showed cell permeabilization at 130 V, accompanied by carbohydrate release. Further increases in plasma output voltage resulted in higher rates of I. galbana cell permeabilization and carbohydrate extraction.

Overall, this study provides the foundation for further investigation and optimisation of plasma treatment as a sustainable and environmentally friendly method for processing microalgae.

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