DEVELOPMENT OF A BUBBLE COLUMN PHOTOBIOREACTOR FOR PHOTOAUTOTROPHIC MICROALGAE CULTIVATION IN THE ABSENCE OF CONCENTRATED CO_2

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ABSTRACT

Despite ample scientific evidence for over three decades regarding the negative impact of anthropogenic greenhouse gas emissions on the earth's climate, the amount of CO_2 released annually from the consumption of fossil fuels is still increasing[1]. The European Union in particular has set the ambitious target of reducing net greenhouse gas emissions by at least 55% by the year 2030 (Regulation EU 2021/1119)[2] which will require the adoption of environmentally friendly, financially sustainable and scalable processes are necessary, including negative emission technologies. Biological processes for the capture, storage and/or utilization of CO_2 are being assessed for their potential to meaningfully contribute towards stabilizing atmospheric CO_2 levels, in addition to established thermochemical CO_2 sequestration processes.

Microalgae, much like terrestrial plants, can sequester CO_2 from the atmosphere through the process of photosynthesis, albeit at much higher rates. Conventional algae bioprocesses sparge a mixture of concentrated CO_2 and compressed air (or O_2) through the liquid culture in order to ensure adequate supply of carbon[3]. However, the use of concentrated CO_2 can increase total production costs by up to $7 per kilogram of dry biomass. Moreover, the poor solubility of CO_2 in water leads to extremely low carbon utilisation efficiencies (~3.5%) causing the majority of sparged CO_2 to escape through the PBR exhaust into the environment. A promising alternative method for the supply of carbon to photoautotrophic algae involving the use of sodium, calcium or ammonium carbonates has been recently presented[4]. Early studies have showed promising results for both approaches, however technical challenges such as the requirement for photobioreactors with exceptionally high volumetric mass transfer rates (k_La).

Herein we present the design, fabrication and experimental validation of a proprietary 1.6L bubble column photobioreactor. The aim is to develop a scalable and affordable cultivation system that can facilitate the optimization of DAC-based algae bioprocesses. Alternative gas/liquid contact installations representing varied levels of contact efficiency and ease of implementation were evaluated. Two different microalgal strains (*Stichococcus sp.* and *Dunaliella salina*) were cultivated in the proprietary PBR both in the presence and in the absence of concentrated CO_2 and results were compared with relevant scientific literature.

KEYWORDS: CO_2 sequestration, Bubble column, Microalgae, Direct Air Capture, Photobioreactors

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