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Growth characteristics of *Chlorella sorokiniana* in airlift and bubble column photobioreactors

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A B S T R A C T

The present study investigated the feasibility of bioCO_2 sequestration using *Chlorella sorokiniana*. It was found that 5% CO_2 (v/v) in air was the most suitable concentration for the growth of this organism. At this concentration, the maximum rate of CO_2 sequestered and the biomass obtained were found to be 1.21 $g L^{-1} d^{-1}$ and 4.4 $g L^{-1}$ respectively. Modeling and simulation of the growth profile was obtained using the logistic equation. Further, at higher CO_2 concentrations, pH drop in the growth media, TAP [-acetate], was prevented by replacing NH_4Cl by $NaNO_3$. Additionally, the study evaluated the performance of two reactors namely: bubble column and airlift reactor based on their growth profile and transport properties like K_La and mixing time. The growth profile was better in airlift reactor and it provides cyclic axial mixing of media. K_La of downcomer was significantly lower than the riser in airlift reactor.

1. Introduction

Global warming has reached an alarming level due to increase in CO_2 concentration in the atmosphere. Recent studies conducted at Mauna Loa Observatory (Hawaii, US) in December, 2011 found that the concentration of CO_2 in air was nearly 391 ppmv. Thus, it is imperative to identify and improve the process of CO_2 sequestration. In view of this, microalgae have been identified as a potential candidate for sequestering CO_2. Besides mitigating CO_2, they are known to have several other uses. They can be used for the production of biofuels (e.g. biodiesel, bioethanol, biohydrogen) and other important products like industrial biofilters, food products and secondary metabolites (Loubiere et al., 2009; Kumar et al., 2011).

Microalgae, *Chlorella sorokinina*, is playing an important role as food and feed because of the multiuse of its biomass previously known to be a rich source of carbohydrate, vitamins, and proteins. The high protein content makes it a suitable raw material for the production of single cell protein (Mahasneh, 1997) while the high vitamin contents makes it a suitable feed for aquaculture systems (Gapasin et al., 1998). Besides, under sulfur deprived condition (Chader et al., 2009) *C. sorokiniana* is also known to produce clean energy, biohydrogen. Additionally, it has been used for the production of commercially important antioxidants like lutein, α/β carotene, α/β tocopherol, zeaxanthin (Matsukawa et al., 2000).

Several factors are known to affect the CO_2 sequestration process; like choice of photobioreactor, culture/strain, temperature, pH, light intensity, culture density, concentration of CO_2, SO_x and NO_x, CO_2 mass transfer, O_2 accumulation etc. (Kumar et al., 2011). Among these, most notably, a suitable photobioreactor is essential for improved CO_2 sequestration and better utilization of light. Ease of operation, scalability, lower land requirement, higher biomass productivity and cost effectiveness are some of the significant features of an ideal photobioreactor (Kumar et al., 2011). Airlift and bubble column were considered as ideal photobioreactors for the present study because they are known to possess all the above-mentioned properties. In the past, both airlift and bubble column photobioreactors have been studied extensively for the cultivation of shear sensitive microorganisms (Barbosa et al., 2003; Chisti, 1989; Suh and Lee, 2001). Similarly, Ranjbar et al. (2008) and Harker et al. (1996) performed studies on airlift photobioreactor for astaxanthin and carotenoids production respectively. However, till date, these photobioreactors have not been completely exploited for the cultivation of photosynthetic microorganisms. A comparative analysis of both the photobioreactors based on the growth profile of the organism, mixing time and volumetric mass transfer coefficient may provide a thorough and comprehensive knowledge of both of the reactors. However, only few studies are available on the interaction of CO_2 mass transfer, light availability, hydrodynamic stress in the airlift photobioreactor (Chisti and Young, 1993; Contreras et al., 1998; Sánchez Miron et al., 2004; Hulatt and Thomas, 2011).

It is well known that alga grows efficiently only at optimal CO_2 concentrations while, any further increase or decrease of CO_2

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