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Short communication

Biosequestration of carbon dioxide, biomass, calorific value and biodiesel precursors production using a novel flask culture photobioreactor

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ABSTRACT

Renewable, carbon neutral, economically viable alternative fuels are urgently needed to turn away the consequences of climate change. Photosynthetic capability of microalgae with respect to CO_2 fixation at various CO_2 partial pressures generated by CO_2 generating buffer ($KHCO_3/K_2CO_3$), increases in biodiesel precursors using IR-CO_2 sensor and modern LED lights-based modern two tier flask photobioreactor has been studied. *Chlorella vulgaris* and *Scenesdesmus obliquus* were found to produce 37.11% and 32.23% of palmitic acid (C16:0) and 30.88% and 39.73% of octadecenoic acid (C18:1) of total fatty acid methyl esters (FAMEs) respectively at 7.5% of CO_2 partial pressure, under the optimal values for growth. Carbon dioxide fixation rate, efficiency of conversion of biomass to calorific value and biodiesel precursors were also estimated.

1. Introduction

Greenhouse gases are responsible for global warming and their major source is fossil fuel. Renewable, carbon neutral, economically viable alternatives to fossil fuels are urgently needed to turn away the impending oil crisis and the spectacular consequences of climate change. Many reports have suggested using flue gas as carbon origin for microalgal cultivation, which could combine biofuel production with current CO_2 mitigation strategies [1–3]. Today, the potential value of microbial, and particularly microalgal photosynthesis to produce biofuel is widely recognized [4,5]. However, the influence of high CO_2 concentration on microalgal growth must

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be investigated [6,7]. Recently, biodiesel fuel has received much attention since it is made from non-toxic, biodegradable, and renewable resources, and its use leads to a decrease in the emission of harmful air pollutants [8], but it will be necessary for the microalgae to have a high calorific value if they are to be used as a biodiesel. The main contribution to the calorific value of the cells is from their carbohydrates, protein and lipid [9,10]. United Nations have imposed carbon credit since 2010 and its estimated carbon prices are reaching up to US $ 270/tonne [10]. Among various strategies for mitigating CO_2, the biological sequestration of CO_2 using photosynthetic microalgae has receiving considerable attention, as microalgae have a high CO_2 fixation capability and produce value added products through their biomass. A variety of microalgae species have been applied in CO_2 fixation, including *Chlorella vulgaris*, *Scenedesmus obliquus*, *Chlamydomonas reinhardtii*, *Spirullina* sp. and *Botrycoccus braunii* [11–13].

The aim of this research was to screen potential microalgae for high carbon dioxide fixation along with disparity in calorific value at a particular partial pressure of CO_2 in a flask culture photobioreactor. The carbon dioxide fixation rate, calorific value and biodiesel precursor of microalgae were also evaluated under different CO_2 partial pressure with a novel IR-CO_2 sensor in LED-light based flask culture photobioreactor experiments.

2. Methods

2.1. Microorganism and culture media

The microalgal cells used in this study were *Chlorella* sp., obtained from the Indian Agricultural Research Institute (IARI), New Delhi, India [6] and *Scenedesmus obliquus*, *Chroococcus* sp and *Chlamydomonas* sp. that were obtained from Environmental Health Division, CSIR-National Environmental Engineering Research Institute (CSIR-NEERI), Nagpur, India. Microalgal strains cultured in the medium BG-11 [14] and incubated at 28 ± 1° 86 C at light intensity of 320 μmol m^{-2} s^{-1} with 16 h light, 8 h darkness (16:8). Flask culture photobioreactor used for cultivation was shaken manually. The microalgae were cultivated for 3 weeks in an enclosed experimental CO_2 set up to investigate their growth characteristics under various CO_2 partial pressures in flask culture photobioreactor.

2.2. Experimental set-up for microalgae growth under various CO_2 partial pressures

The microalgal cultures as mentioned above were incubated in culture flask photobioreactor made up of a 250 mL Erlenmeyer flask (Top) and a round bottom flask (Bottom). The set up is shown in Fig. 1 with the upper flask for microalgal growth and the lower flask contains 100 mL of CO_2 generating buffer mixture ($KHCO_3/K_2CO_3$) and buffer was replenished after every 48 h to keep CO_2 partial pressure constant. The accurate CO_2 partial pressure in headspace of the flask was optimized to 1.4%, 3.0%, and 7.5% by using different concentration of buffer mixture and monitored by infra-red CO_2 sensors along with one flask kept as control without buffer. The flask system's working volume of 100 mL was kept air tight by using parafilm. Light intensities, temperature and CO_2 concentrations were kept constant in accordance with the above mentioned microalgal growth conditions.

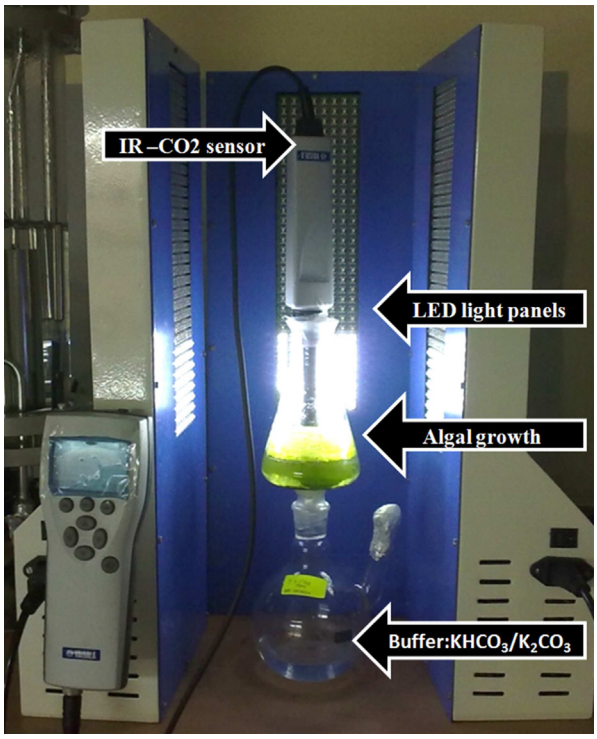

Fig. 1 – Experimental set up showing culture flask photobioreactor with IR-CO_2sensor at the top of upper flask, artificial CO_2 generating buffer ($KHCO_3/K_2CO_3$) in the bottom flask and LED based light panels.

2.3. Determination of dry cell weight

The dry cell weight was measured by filtering aliquots of known cell numbers on pre-weighed GF/C filter paper (Whatman, UK). The filtered cells were dried at 80 °C for 24 h.

2.4. Light intensity

Light intensity was provided by three Light Emitting Diodes (LED) panels and determined with light meter (LX-107HA, USA). This light meter gives a reading in Klux that can be converted to μmol m^{-2} $s^{-1}$for the measured light intensity (1 Klux = 19.5 μmol m^{-2} s^{-1}).

2.5. Carbon dioxide (CO_2) determination

Carbon dioxide concentration was analyzed by iBRID MX6 sensor (Industrial Scientific, UK) and CO_2 partial pressure in experimental set up was also cross checked by an Infra-Red CO_2 sensor MI 70 (Vaisala, Finland).

2.6. Determination of calorific values (CV)

The calorific values of dried algal cells were determined using a Digital bomb calorimeter (Optical Technology, Delhi,