



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The growing atmospheric emission of greenhouse gases (GHG), especially CO₂ from the combustion of hydrocarbon fuels currently hold significant impact on the increasing global carbon footprint. As a global concern, this situation has mandated the search for feasible carbon capture strategies (CCS). To that end, biological CCS offer sustainable methods free from energy intensive and complex chemical treatments. Microalgae, a natural and efficient cell factory for CO₂ capture, have gained impetus owing to its faster growth rate compared to other terrestrial plants, marginal cultivation requirements and diverse product portfolio. However, commercial feasibility of microalgae-based carbon capture and product generation process lies on several factors, which motivated the current research.

At the onset of the present study, the search of suitable microalgal strain with high CO₂ sequestration capability was materialized through screening of carbon rich industrial effluent using novel CO₂ selection pressure-based strategy. *Tetrademus obliquus* CT02, an indigenous microalgal strain isolated through the novel screening process, found to exhibit a high CO₂ tolerance of 20% v/v. In order to understand the elementary requirements, the growth of the isolated microalgal strain was evaluated under different medium, initial pH and limiting nutrient (Nitrogen and phosphate) sources. Under selected nutritional and growth conditions, CT02 was found to have high protein and lipid content of 35.96% w/w and 41.21% w/w respectively, which clearly hypothesized the presence of vast product array. Keeping in mind the evident drawbacks of single product strategy, a biorefinery approach has been adopted for the isolated microalgal strain towards synthesis of different value-added products. Bioprospecting was performed in two sequential steps, resulting in alternate product cascades of bioactive molecules and biodiesel or biofertilizer. In the first step, crude microalgal extracts in five different solvents were screened for their antioxidant and anticancer activities. While acetone extract showed the highest antioxidant activity with an IC₅₀ value of 137 µg mL⁻¹, ethyl acetate extract exhibited maximum anticancer activity with an IC₅₀ value of 306.67 µg mL⁻¹. This antioxidant and anticancer activity may be attributed to the coordinated action of multiple bioactive molecules as detected by HR-LCMS analysis. In the next step, post extracted residual biomass of CT02 was evaluated as feedstock for biodiesel production. The lipid content was found to be 35.7% - 39.1% w/w and further to that, FAME yield of 33.1% - 36.7% w/w was obtained via direct transesterification of both the acetone and ethyl acetate extracted biomass. Analysis of

FAME composition revealed an abundance of palmitic acid (C16:0), stearic acid (C18:0), and elaidic acid (C18:1n9t) as the major constituents, making it suitable for use as biodiesel. The post extracted residual biomass was also evaluated for its application as biofertilizer through induced germination of *Solanum lycopersicum* seeds. The highest final germination percentage and germination index was estimated to be in the range of 75% - 80% and 117.5 - 118.5, respectively, comparable to that of commercial grade NPK (20:20:13).

Following the successful demonstration of biorefinery concept for CT02, a process engineering strategy was developed targeting improvement in its growth performance. The basic premise of the process relies on pH guided feeding of CO₂, enabling the growth of the isolate at optimal pH and without experiencing any possible limitation of carbon source. CT02 was first subjected to optimization of cultivation parameters under laboratory scale followed by evaluation of its growth and culture pH under diurnal variation of simulated sunlight intensity. The understanding of interdependent dynamics between growth, culture pH and incident light intensity led to the development of pH-based CO₂ feeding process for growth under quotidian variation of light intensity. The strategy was developed at laboratory scale bubble column photobioreactor under diurnal variation of simulated sunlight intensity and was further validated through growth of the strain in a 100 L airlift bioreactor under fluctuating outdoor environmental conditions, which considered to be economical way of biomass generation. Under laboratory condition, an improvement of 53.3% in biomass titer and 85.16% in biomass productivity was achieved as compared to the batch with uncontrolled pH. The positive impact of the strategy was more prominent even under outdoor condition where, biomass titer and productivity of 1.14 g L⁻¹ and 59.4 mg L⁻¹ day⁻¹, was an improvement of 225.7% and 121.6% respectively, compared to the pH uncontrolled batch. In context of CO₂ fixation rate, 121 % improvement was achieved at outdoor cultivation process engineering strategy compared to batch with uncontrolled pH.