INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Process design for production of lipid rich microalgae in a bubble column photobioreactor equipped with membrane-sparger and internal mixer

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SHORT ABSTRACT

Despite the superior renewable source of biodiesel, microalgae cultivation technology has been facing commercial challenges such as inefficient photobioreactor (PBR) design and low biomass yielding open pond practices. The major process factors for outdoor microalgae growth are reactor design, CO_2 feed, and sunlight availability. Therefore, an innovative PBR with effective light penetration and sustainable CO_2 feed strategy is imperative to design an economical algae-biodiesel plant. As an experimental strain, a pre-qualified biodiesel candidate, *Chlorella* sp. FC2 IITG (FC2) was used in the study. Based on the benefits offered by vertical tubular PBRs over the open ponds, horizontal tubular, and flat panels, a bubble column PBR (BC-PBR) was constructed with high CO_2 mass-transfer efficient membrane-sparger. Using the membrane-sparger equipped BC-PBR, the effects of constant lighting and constant CO_2 feed conditions on FC2 growth were evaluated to understand the combined effect of light and CO_2. Consequently, 'maintenance of 100 mg L^{-1} dissolved CO_2' was determined as optimum in small-scale (500ml, 0.175m height) BC-PBR under simulated sunlight conditions. For medium-scale (10L, 2.75m height) BC-PBR, a novel light intensity based CO_2 feed was developed as efficient and scalable strategy over known strategies like constant feed, biomass-density based feed, and pH-control based feed strategies under simulated sunlight conditions. With the strategy, FC2 could achieve cell-density of 9 g L^{-1} under natural sunlight with a biomass productivity of 0.85 g L^{-1} day^{-1}. Furthermore, a specially designed self-rotating and bubble-driven internal mixer was integrated inside the BC-PBR for improving sunlight penetration, thereby enhanced biomass as well as biodiesel productivities. Notably, the mixer does not require extra aeration or electrical energy for its rotation. The process after the mixer integration could achieve highest biomass productivity up to 1.5 g L^{-1} day^{-1} and overall biodiesel productivity of 521 mg L^{-1} day^{-1}, higher than any reported literature. The final biodiesel production in medium-scale BC-PBR equipped with membrane-sparger and internal mixer was 3.7 g L^{-1}. To the best of author's knowledge, this is the first study to report a novel light intensity based CO_2 feed strategy and a bubble-driven internal mixer for algae-biodiesel technology. Moreover, the experimental microalgal strain used in the study does not require pH-control, shown biomass growth instead of loss in dark cycles of culturing, and possesses irreversible photoinhibition phenomenon even at peak sunlight intensity of 2000 μmol m^{-2} s^{-1}. Therefore, the designed process technology can open a new dimension for future developments in algal biodiesel production research.