Abstract

The advent of the 21st century has led to global energy crisis. Anthropogenic activities have accumulated to the twin crises of fossil fuel depletion and environmental degradation. These have paved way for the search of renewable sources of energy. Among biofuels, 3rd generation feedstock (such as microalgae) are gaining importance. Microalgae can potentially be employed for the production of biofuels. Algae contain different amount of lipid and depending upon the species and growth conditions the lipid content can vary from 10-50 %w/w of algal biomass. Present study implements the idea of strategic cultivation of *Neochloris oleoabundans* UTEX 1185 with concomitant CO_2 sequestration for subsequent downstream processing of biomass constituents into biodiesel. *N. oleoabundans* UTEX 1185 was found to be suitable for lipid production. Lipid production from microalgae depends on the biomass concentration and its lipid content. Suitable physico-chemical parameters viz. initial pH, cultivation temperature and nitrate concentration were determined in shake flask (250 mL) using single parameter optimization techniques for the improvement of biomass production. Taguchi model revealed that temperature was the most influential parameter. Through single and multi-parameter optimization studies, biomass concentration of 1.55 g/L with lipid content of 40 %w/w was obtained. The biomass concentration was increased to 2.01 g/L and the lipid content was enhanced by 6 % in bubble column reactor as compared to conical flask under the optimized conditions. Stoichiometric analysis revealed that 1 g of algal biomass fixed 1.503 g of CO_2 from air and releases 1.506 g of O_2. Reactor configuration and hydrodynamics considerably influence biomass and lipid productivity from microalgae. In the present study, four different configurations of photobioreactors namely, airlift and bubble column each with orifice and ring sparging were considered. Volumetric mass transfer coefficient, mixing time, and shear stress were analyzed at different air flow rates. Bubble column with ring sparger was found most suitable. Two-phase Eulerian CFD model was considered to find out the influence of different flow rates on mixing time. The developed CFD model corroborated well with the experimental findings (3.65 % deviation from the experimental values). The study is followed by improvement of biomass and lipid production by mixotrophic cultivation (using glucose). ^{13}C-Metabolic flux analysis on lipid production of microalgae was also studied. Lipid extraction process using auto-flocculated wet microalgal biomass with different pretreatment methods was developed. Autoclave pretreatment showed better intracellular lipid extraction capacity. This is believed to reduce the major cost of drying and harvesting of the microalgal biomass. To diminish the adverse effects of using acid and base as catalyst in the transesterification process, the effect of Fe_2O_3 nanoparticles as a heterogeneous catalyst was studied. The Fe_2O_3 nanoparticles were synthesized from plant extract. Higher biodiesel yield was evidenced with Fe_2O_3, as compared to HCl and NaOH as catalyst in the transesterification reaction. Transesterification process parameter optimization led to 86 % of biodiesel yield from the lipid. FAME analysis and fuel properties indicated the suitability of *Neochloris oleoabundans* UTEX 1185 biomass as a feedstock. Overall Life Cycle Assessment (LCA) revealed that the process using Fe_2O_3 nanocatalyst in the biodiesel production process and lipid extraction from the wet microalgal biomass has reduced environmental footprints as compared to that of the conventional biodiesel production process.

Keywords: Microalgae; *Neochloris oleoabundans* UTEX 1185; Taguchi model; Computational Fluid dynamics (CFD); Metabolic Flux Analysis (MFA); Biodiesel; Transesterification; Life cycle assessment (LCA).