Abstract

Microalgal biodiesel production experiences hurdles in every step, starting from cultivation followed by harvesting, drying, oil extraction, transesterification and overall, the cost of production. An approach was made in minimizing the cost of biomass production using the locally available agricultural fertilizers, viz. urea, NPK, diammonium phosphate, potash, magnesium sulfate and superphosphate as macronutrients, and fertilizer-grade copper sulfate, ferrous sulfate and zinc sulfate as micronutrients for cultivation of the green microalga *Scenedesmus obliquus* (Trup.) Kutz. (SAG 276-3a, Gottingen, Germany). The optimized urea medium (OUr) depicted a cost reduction by 50-fold as compared to the N 11 control medium. The biomass yield was enhanced by 33.5% with reduction in the requirements of the major nutrients, such as potash by 29%, magnesium sulfate and superphosphate by 25% following optimization. Urea requirement was however, increased by 20% in the newly formulated OUr medium. The latter was also found suitable for cultivation of other eight green microalgal species, viz. *Scenedesmus accuminatus, Scenedesmus armatus*, *Chlamydomonas* sp., *Haematococcus pluvialis*, *Chlorella sorokiniana, Chlorella vulgaris, Chlorella minutissima* and *Selenastrum* sp.

The pilot-scale cultivation of *S. obliquus* in open raceway ponds in OUr medium depicted maximum biomass and lipid yield of 1.23 g L^{-1} and 125.3 mg L^{-1}, respectively, at 30 cm culture depth with 65 rpm impeller speed on 30th day of cultivation during winter season. Thus the areal biomass and lipid productivities were estimated to be 12.61 and 1.2 g m^{-2} day^{-1}, respectively for the winter season followed by summer (10.89 and 1.08 g m^{-2} day^{-1}, respectively), and least for rainy season (4.75 and 0.42 g m^{-2} day^{-1}, respectively).

Various harvesting techniques, viz. pH-induced flocculation, use of inorganic chemicals, cationic polymer, dissolved air flotation and electro-flotation were studied to harvest the microalgal crop economically in an eco-friendly way. Among them, the pH-induced flocculation by NaOH was found to be the most pertinent one for pilot-scale cultures. Moreover, the supernatant was reused as growth medium with nutrient re-supplementation and pH adjustment.

The harvested microalgal slurry was hydrothermally processed for the production of bio-crude/bio-oil. Hydrothermal liquefaction was standardized at 300°C, 200 bar pressure and 60 min of residence time. The use of CH_3COOH as catalyst increased the bio-crude yield to 45% (wt.%), thus resulting an increase by 10% with catalyst use. The higher heating value of both petro-crude and bio-crude was found to be in the same range. The bio-crude however, showed higher oxygen and nitrogen contents, thus demonstrating the need for hydrodeoxygenation and upgradation for better stabilization of bio-crude.

Keywords: Agricultural fertilizers; Bio-crude; Harvesting; Hydrothermal liquefaction; Microalgae; Raceway pond cultivation; *Scenedesmus obliquus*.