

Review Article

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Third-Generation Biofuels: An Alternate Strategy

Sonam Antil*

College of Basic Sciences and Humanities, CCS HAU, Hisar, Haryana 125004, India

*Corresponding author

ABSTRACT

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Rapid industrialization and high population growth are two major reasons contributing to the global energy crisis. Today, almost 88% of worldwide energy consumption is a consequence of the combustion of fossil fuels. Biofuel production from renewable energy sources is largely considered as one of the most sustainable strategies to shift from petroleum based fuels and a considerable means for environmental and economic sustainability. Microalgae are recently being regarded as an ideal third-generation biofuel feedstock because of their fast growth rate, the high lipid production ability and capacity to fix CO₂. These also do interfere with food or feed crops and can be grown on non-agricultural land. In this review, the use of microalgae for biodiesel and bioethanol production, including their cultivation, harvesting, and processing to yield biofuels will be discussed.

Introduction

Biofuels are solid, liquid or gaseous fuels derived from organic matter. The major issues like the depletion of fossil fuels, energy security, increasing petroleum prices, and global warming are paving a way to growing worldwide interests in renewable energy sources such as biofuels. Biofuels have energy that is stabilized through the process of biological carbon fixation, in which carbon dioxide (CO₂) is converted into glucose that is only present in living organisms such as plants. In comparison to fossil fuels, biofuel is

produced by living organisms in a relatively short duration of time instead of being derived by the decomposition of organic matter over several million years (Alaswad *et al.*, 2015).

Till recent times, the waste products of food were considered as the feedstock for biofuel production.

Recently, the emphasis is on various highly productive organisms to yield biofuel and the likelihood of microalgae as the next generation of biofuel feedstock. At present, microalgae are being considered as a perfect

feedstock for third-generation biofuel due to their fast growth capacity, reduction in greenhouse gas emission, and high lipid (oil) production rate

Types of biofuels

Biofuels are normally classified into two classes: primary and secondary biofuels. Primary biofuels mainly consist of fuel wood which is used in an unprocessed form majorily for heating, cooking or electricity production while secondary biofuels are bioethanol and biodiesel which are obtained by processing biomass that are used in vehicles and various industrial processes. The second type of biofuels further categorized into three generations based on different parameters like, processing technology type, nature of feedstock or development levels (Nigam *et al.*, 2010). Although biofuel have a great potential to provide an alternative to fossil fuels, first-generation production systems have high environmental and economy related limitations while the main problem with second-generation biofuels is converting the complex lignocellulosic biomass into fermentable sugars which requires costly pretreatment techniques.

Therefore, third generation feedstock or microalgae based biofuels are considered to be a productive alternative energy resource that is free of the major drawbacks associated with first and second-generation biofuels (Chisti, 2007; Li *et al.*, 2008, Schenk *et al.*, 2008; Brennan and Owende, 2010).

Importance of Microalgae

The thought of using microalgal feedstock is not a new one. The continuous depletion of natural fuels and rising petroleum prices are the main reasons that the focus has been put on microalgal based fuels. The utilization of microalgal feedstock for producing biofuels

has many advantages when compared to higher plants. Microalgae naturally synthesize and concentrate large quantities of neutral oils (20–50 % dry weight of biomass) and has a high growth rate. There is whole year production, hence more oil yield.

Also microalgae need less water, do not require herbicides or pesticides application, reduce emissions of a major greenhouse (CO₂). These can tolerate harsh conditions for growth and have reduced need for nutrients (Um and Kim, 2009; Mata *et al.*, 2010).

Microalgae cultivation system

A microalgal cultivation system must have properties like high area productivity, high volumetric productivity, economical feasibility (both in terms of investment and maintenance costs, easy control conditions (temperature, pH, O₂, turbulence) and dependability for commercial scale production.

Different types of microalgal cultivation systems try to accomplish these characteristics in their own ways. Photobioreactors are basically used for microalgae cultivation. Despite the term photobioreactor (PBR) is enforced to open ponds and channels, scientists have differentiated between open-air systems and PBRs (preferably monoseptic cultures) (Dragone *et al.*, 2010).

Harvesting Methods

Harvesting of microalgal biomass can be done by several physical, chemical or biological ways like Flocculation (which is an initial dewatering step in the bulk harvesting process for enhancing the ease of further processing), Centrifugation (in which centrifugal forces are used to separate microalgal biomass from the medium), flotation, filtration, etc.

Microalgal lipid extraction

This includes various steps like Biomass drying (spray drying, drum drying, freeze-drying, fluidized bed drying and reflectance window dehydration technique), Cell disruption (autoclaving, high-pressure homogenisers, and addition of strong acids and bases like hydrochloric acid, sulphuric acid, sodium hydroxide, or alkaline lysis) and Lipid extraction (solvent extraction, expeller/oil press., supercritical fluid extraction (SFE) and ultrasound techniques)(Brennan and Owende, 2010; Harun *et al.*, 2010)After extracting oil from microalgal biomass, it can be converted into bioethanol and biodiesel.

Challenges faced while using microalgae

When microalgae is used as feedstock for biofuel generation, many challenges come into way like technical issues with the fuel flow, huge amount of land is required for growing microalgae, high production cost and unknown retail price. Further research is needed in this field for commercial application for microalgal feedstock.

Future perspective

Microalgae acts as sustainable third generation feedstock for the production of biofuels like biodiesel and bioethanol. However, there are several considerable scientific and technical barriers need to be overcome before the commercial scale production of microalgae derived biofuels.

Development of technologies like advances in designing of photobioreactor(PBR), harvesting, drying, and processing of microalgal biomass to yield biofuels are important areas that need to be researched which may lead to increased cost-effectiveness and hence, effective application

of the biofuel from microalgae strategy on a commercial scale.

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