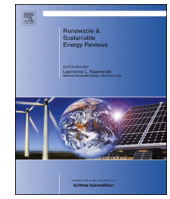
Renewable and Sustainable Energy Reviews 47 (2015) 634–653

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



Aquatic biomass (algae) as a future feed stock for bio-refineries: A review on cultivation, processing and products

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ARTICLE INFO

Article history:
Received 20 June 2014
Received in revised form
25 October 2014
Accepted 8 March 2015
Available online

Keywords:
Biofuels
Biodiesel
Downstream processing techniques
Algal farming
Macroalgae
Microalgae

ABSTRACT

Global outlook of biofuels turns out to be a full-fledged search focusing the viability and sustainability assets. The present day option for immediate and sustainable alternate fuels lies with algal biofuels. Algae are the most sustainable fuel resource in terms of food security and environmental issues. Inefficient and unsustainable biofuel derived from food crops twosome food security issues thus increasing interests towards algal energy. CO_2 mitigation, quick biomass accumulation accomplishing simultaneous bioremediation have gathered progressive attention. Cultivation of biomass, harvesting, processing and fuel production by chemical/biochemical reactions are the sequential stages in algal biofuel production. Currently, biofuels produced from algal biomass is not economical since biomass cultivation, processing and separation of fuel products appears costly although certain advancements in culturing techniques have been recently unearthed. Further improvements with the biomass processing strategies may step up the third-generation biofuel concept a profitable one in the near future. This article reviews various cultivation methods, processing techniques and stages in algal biofuel production thereby extensively investigating their potential application in biofuel refineries.

Contents

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http://dx.doi.org/10.1016/j.rser.2015.03.047

1. Introduction

Energy security is a major issue faced by countries all over the world. The increasing energy consumption has dropped the fuel resource by maximum. The total global petroleum consumption is still increasing due to intensified energy consumption. In 2007, there were 806 million cars and light trucks [1] which is expected to increase up to 1.3 billion by 2030 and 2 billion by 2050 [2]. Currently, one-fifth of the global CO_2 emission is due to transportation and trucking. It is critical to realize the negative impacts imparted on the global environment by fossil fuels that has drifted the exploitation of alternate fuels. The green replacement of fossil based petro fuel is the trending strategy that has gained much attention from scientists all over the world. Biofuels have the potential to replace existing conventional fuels, reinforce energy security and reduce the emission of both greenhouse gases (GHGs) and other air pollutants. Biofuels are considered sustainable, renewable and environment friendly fuels. Biofuels such as bio-ethanol, bio-butanol and bio-diesel are produced from sugar beet, sugar molasses, soybean or rapeseed. Biodiesel is alkyl esters obtained from transesterification of fatty acids obtained from renewable biomass. Biodiesel is a proven fuel and its production and processing techniques are known for more than 5 decades. Biomass fuels potential include wood, short-rotation woody crops, agricultural wastes, short-rotation herbaceous crops, animal wastes, and a host of other materials. Various sources of hydrocarbons used in commercial biodiesel production include canola oil, animal fat, palm oil, corn oil, jatropha oil and waste cooking oil. Using agricultural crops as biofuel feedstock denotes competing with food production as large quantity of fresh water and land supply is needed which raises serious issues on raw material sustainability [3,4]. However currently 95% of world's biodiesel is produced from edible oils [5]. This concern is discussed as food versus fuel dispute in long term vision where food scarcity will be the consequence if considering agro crop based biofuel production. Though there are several other non-edible oil sources, sustainable production of land based non-edible biomass is difficult to feed large scale biodiesel plants. Due to rolling food cost from the competition, global economies have become unstable since 2006 and the global food stocks of major grains such as rice, wheat, and corn were at their lowest for the past 2 decades. For countering these reasons, algae based biofuel production progressed recklessly in the midst of biofuel research.

Autotrophic micro-organisms such as algae seem to be a promising way out for unceasing energy appetite [7]. Algae can be directly converted to energy. The hydrocarbon content of algae distinctively the fatty acid (FAs) and acyl glycerides [8] have the potential to counter the diminishing fossil assets [9]. The oil extracted from algae can be used for biodiesel production. The residual biomass rich in sugar fraction can be used for production of bio-butanol and bio-ethanol by fermentation. The algal cells suspended in nutrient rich water acts as a reliable bio-mechanism that efficiently converts nutrients and CO_2 to hydrocarbons. Microalgae are photosynthetic micro-organisms that convert sunlight, water and carbon di-oxide to algal biomass [10]. Microalgae are being explored at a faster rate as potential oil source for biodiesel production. About 25,000 species are reported out of which only 15 are employed as commercial oil producers [11]. Active researches are promoted in the field of micro-algal biodiesel in scope of evaluating it as a potential source for sustainable biodiesel production. On the other hand, macroalgae commonly called as seaweeds remain as untapped marine mysteries for fuel production. Only few investigations have been reported for macro-algae based biodiesel. Marine macroalgae is a potential biomass for biofuel production because of their higher productivity rates than terrestrial biomass such as corn and switch grass [12]. Annual biomass production of macroalgae is too high [13] and the ease degree of maintenance in large scale cultivation of marine seaweed serves as a key factor for using marine macroalgae as biofuel feedstock. Although many researchers have been trying to utilize lignocellulosic biomass that is not used for food, this biomass can still incur the same environmental consequences associated with land use and water consumption [14]. Thus, terrestrial biomass-based bio-refinery seems not to be sustainable choice for scale up at present due to environmental as well as economic impacts. Microalgae and marine macroalgae have the high potentials to fully and partly displace terrestrial biomass and produce sustainable bioenergy and biomaterials. This review focuses the technical aspects of algae based biofuel production and its potential to replace fossil fuels.

2. Algae

Algae are diverse group of photosynthetic organisms ranging from unicellular (Microalga) to multicellular (Macroalgae) forms. They have chlorophyll as primary photosynthetic pigment and do not have a common ancestor. Commonly, algal population falls under two broad categories (1) Microalgae: Microscopic algae that grows in fresh water and marine environment and (2) Macroalgae: Comparatively large, multicellular organisms that grows in marine environment. There are two main populations of algae: filamentous and phytoplankton algae. These two species, in particular phytoplankton, intensifies rapidly to form algal blooms [15]. Though the main storage compound of these algae is starch, oil can also be produced or induced to accumulate within the biomass. The faster growth rate and greater lipid content of microalgae compared to oilseed crops urge researchers to develop technologies for algae utilization in biodiesel production instead of plant oils [16]. Algae based biofuel production has very less degree of intrusion in the food versus fuel dispute of tomorrow which is an added advantage [17].