Bioethanol Production from Algae Biomass: A Short Review

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Abstract

World population crossed the mark of 7.5 billion and constantly increasing. Growing world population demands the energy supply, currently, about 80% of energy source come from fossil fuels. If this energy consumption trend continues the world fossil fuel reserve will run out at the end of 2050. About20% bioethanol is allowed to blend with fossil fuel which runs the present engine without any modification. Ethanol blended fuel is called gasoline and it can reduce air pollution and global warming. The increasing price of fossil fuels and the bioethanol production from the starchy material raised the issue of food vs. fuel crises have led to the quest for renewable biofuel from algal biomass. Algae are now being considered as the third generation biomass for bioethanol production.Algal biomass contains a huge amount of cellulose and starch that can be a feedstock for bioethanol production. Algal biomass can be pretreated and saccharified to release fermentable sugar and allowed to anaerobic fermentation to get bioethanol. This review summarizes the current status of bioethanol from algal biomass, important steps of bioethanol production, and the major commercial challenges

Keywords: Bioethanol; algae; algal biomass; Saccharification; fermentation

1. Introduction

The demand for fossil fuels is anticipated to grow by 40 % from 2010 to 2040 [1]. Therefore to satisfy our energy need, alternative energy source been explored. First-generation biofuel (starch-based) limited because it rises the fuels vs food conflict has sparked the interestin exploringn on food based low-cost renewable materials, one such material is microalgae [2.4] Second generation (lignocellulose) biomass for ethanol is not exploded for bioethanol production because it is very difficult to digest. [3] Besides, agriculture-based crop for bioethanol production is over burden as they require a large amount of land and water to grow. There is a significant interest shown by the researchers to produced algae-based biomass (Third generation) for bioethanol production, as algae do not need arable land and fresh water to grow. A large amount of starch accumulates in algae make them good feedstock for bioethanol production[4]. Algae are classified as macroalgae and microalgae. Microalgae are either eukaryotic or cyanobacteria [4.5.6]. Microalgae are photosynthetic microorganism with a cell size between 2-200µm. Microalgae are reported to contain about 50-60 % carbohydrates. [10]. Bioethanol can be produced by three types of steps, 1) pretreatment 2) Saccharification 3) fermentation. One of the most important steps is the pretreatment of algal biomass with acid, alkali or enzymatic method to release the polysaccharide into oligosaccharides. In case of Saccharification process, cellulose and starch converted into fermentable sugars. the final steps, fermentable sugars are allowed to fermentation with yeast, bacteria or fungi to produce bioethanol. Researches manage to produce about 11% amount of bioethanol [11]

2. Overview of algal biomass

Algae are the diverse groups of photosynthetic organisms. The rate of biomass production of algae is mor compared to crop plants [12]. Most algae grow in a wide range of temperature between 20 to 30^{0}C and withstand extreme conditions. Microalgae can accumulate a large number of carbohydrates, proteins and lipid storage compound inside the cell [12.13] algae produce a large amount of biomass using photosynthetic proc Algae biomass are reported to contain lipid, protein and carbohydrates depending on the species and gro conditions [15]. microalgal biomass can solve food vs fuel conflict[16],algae can be grown in wastewater produced biomass rich in carbohydrate (50%) which is the main fees stock for bioethanol production.

3. Pretreatment of algal biomass

Acid and alkali based treatment of algal biomass releases a large amount of furfural and 5 hydroxymethylfurf which inhibit the fermentation ability of microorganism. Treatment with the biological method is most wi accepted and it is ecofriendly, many enzymes from microorganism are exploited to release oligosaccharide f algal biomass. Enzyme based hydrolysis can be operated with fewer requirements and hence it can industrialized. Enzymes from microbes are costly [17]. Cellulase, amylase and amyloglucosidase were used pretreatment. Endo β-(1-4) D-glucanase converts algal cellular polymerase into simple sugars. Exo –β-(glucanase breakdown cellulose into disaccharide and β- glucosidase breaks the glycosidic bond into glucose maltose. Proteases are used to hydrolyze the complex polysaccharides into oligosaccharides and peptides. low-cost pretreatment with amylase and cellulase treatment was reported [18].

4. Saccharification

After the pretreatments with acid-alkali or enzymes, the residual algal biomass saccharified to the release la amount of the fermentable sugars. Fermentable sugars such as glucose,mannitol, mannose and fructose ar assessable by yeast or bacteria to produce bioethanol. Microorganism such as *celluomonas, Aspergillusnige* , *Bacillus*sp are communally used for the Saccharification. Saccharification of algal biomass release fermenta sugar and do not produce toxic metabolites like furfural and finally higher yield of simple carbohydrates [12, 17

5. Starch and total carbohydrates determination methods.

The carbohydrates present in algal biomass are the simple sugar and the starch; therefore it is very importan know the technique used for the quantification of these molecules. Evaluation of starch in microalgae biom using different techniques was reported [11] among these the most and simple is perchloric acid method. in i method microalgal pigment can be extracted with solvents like hexane, acetone or ethanol and the starch mole can be extracted and solubilize with perchloric acid method and finally, the total sugar is quantified by Anthr method or phenol sulfuric method.

6. Fermentation

Fermentation is the biological process whereby simple sugar converted to bioethanol by the action of fermenta microorganism under anaerobic condition. Fermentable sugar such as glucose, fructose, maltose and rhamnose used as a substrate by microorganism in the fermentation process, which convert them into ethanol and car dioxide [9, 12, 26]. Several types of microorganisms tabulate in table 1 involves in the bioethanol produc Bacteria like *Z. mobilis, L. fermentum, W. confusa* and the yeast such as *Saccharomyces cerevis Schizosaccharomyces cerevisiae* are commonly used in the ethanol fermentation.

The quality and quantity of the bioethanol production strongly depend on the optimum conditions, types substrate and the organism used [19,21]. Algal sugar is an excellent carbon source for biocthanol productior stated above, some species of microorganism are useful for bioethanol production due to sugar utilizing abili under anaerobic condition.

Table 1 List of microorganisms used in bioethanol production

Microorganisms	Stain	Sugar used
Yeast	*Saccharomyces cerevisiae*	fructose, glucose
	Schassromycescerevisiae	fructose, glucose, xylose
	Candida shehatae NCL-3501	Co-ferment xylose and glucose
Bacteria	*Z. mobilis*	Xylose ,arabinose, glucose and xylose
	W. confusa	glucose
	L. fermentum	mannitol

7. Trends and challenges of bioethanol production from algae

Bioethanol production worldwide has strongly increased since the oil price has immensely increased. Brazil is world leader to produced ethanol from sugarcane and used as an additive in fossil fuel as gasoline [19]. In Uni States corn and sugar beet used for ethanol production. UAE proposed running about 10% of its transport biofuel by 2020. The US proposed to replace 20% of its road transport fuel by 2020. The renewable Transport f Certificate (RTFC) would be granted for fulfilling this need by proposing the third generation biomass. By year 2070 renewable energy is expected to dominate. The first generation bioethanol raises the issue of food fuel crises, to overcome this conflict bioethanol production from second-generation biomass like lignocellul was proposed by world scientific community, and still, there is a challenge to hydrolyze the non-food feedsto recently the third generation biomass from algae is proposed for bioethanol productions.Algae are the m sustainable organism for the developments. Microalgae are photosynthetic organism uses carbon dioxide a reduced greenhouses gases, besides this, they cannot require arable land and fertilizer. The key challenge lays cultivate in the wastewater, a large number of the viral and bacterial pathogen may parent in wastewater and ha

to algal growth. weedicides run out from the farm also decrease the efficiency of algal growth [33]. An important challenge in algal cultivation is the selection of suitable strain, site selection, isolation, purificatior identification of algae is a time consuming and tedious. Naturally, some algae do not need artificial s improvement they grow better with natural conditions but the key challenge is the optimization of gr conditions. To producer bioethanol from algal biomass, the hydrolysis of algal biomass with is the challenge.[27] There are three steps for bioethanol productions.1)Pretreatment of algal biomass2) Saccharifica of algal biomass 3) fermentation. These three steps takes more time and make infeasible to commercialize a biomass for bioethanol production, to solve this challenge novel bacterial species need to create in such a way it can produce extracellular enzymes to hydrolyzed the algal cell wall and release fermentable sugar in aer environment in first steps and in the second steps the same bacterial stain under anaerobic condition utilized suga: to produce bioethanol by fermentation process. Such a novel stain can be developed in the coming futur tackle these energy crises,

Conclusion:

The first generation and second generation biomass for bioethanol production have certain limitations, research gap can be full filled by the algae biomass.Algae are now being considered as third generation biom for bioethanol production. Algae biomass contains a large amount of the cellulose and the starch, and the grov rate of algae is more than the crop plants. In addition to this algae cannot compete with crop plant for arat and water hence algae are a suitable candidate for bioethanol production, in this short review we focused o methods used to extractfermentable sugar from algae and the methods of total sugar and starch estimation. T study also focused on the ability to fermentmicroorganism and the recent challenges regarding the possibility stain improvement for biomass Saccharification and ethanol production.

References

1. A.I. Reda, J.H. Abou-Shanab, C. Yunchul, M. Booki, J. Byong-Hun, 2011 Appl. Energy .212-219
2. Abo El-K,El-Sayed.B, ,R.Hamed. 2015. Complementary Production of Biofuels by the Greer Chlorella vulgaris, International Journal of Renewable Energy Research,Vol 5 (3) .935- 943
3. Abouel-Fotouch A.M, Attia,N.K.,ElDiwani,G.S. Abo El-Enin . 2015. Biomass production from blue gre algae microalgae under nutrient stress, International Journal of Chem Tech Research,Vol (8) 483-489
4. Alexander N. Glazer, Hiroshi N .2007. Microbial Biotechnology Fundamentals of Applied Microbiolog Cambridge University Press, 1-554
5. Anderson P.J, McNeil. K, Watson. K.1989.Appl. Environ, Microbial, Vol (51) 1124
6. Annamali, J and Nallamuthu,T .2015. Characterization of biosynthesized gold nanoparticle from aqueou extract ofChlorella vulgaris and their ant pathogenic properties, App.NanoSci ,Vol (5) 603-607
7. Borowitzaka.M.A.2008.Marine and halophilic algae for the production of Biofuels, J. Biotechnol, V (13) 136: 57