International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-9, Issue-3, May 2021
https://doi.org/10.55524/ijircst.2021.9.3.27
Article ID 219327, Pages 134-138
www.ijircst.org

A Critical Review of Lignocellulosic Waste Pretreatment for Biofuel Production

Garima Awasthi

Associate Professor, Department of Agri-business Management, Vivekananda Global University, Jaipur, India

Correspondence should be addressed to Garima Awasthi; garima.awasthi@vgu.ac.in

Copyright © 2021 Made Garima Awasthi. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT- Environmental protection is a top priority, and this can only be accomplished by minimizing Chemicals are used in the manufacturing of fuel. As a biofuel source, bioethanol production waste has become more and more attractive. Using a proper pretreatment technique, it may be transformed into a useful form for biofuel generation. Researchers have employed a variety of pretreatment techniques, including physical, chemical, physicochemical, biological, and combination pretreatments. Because a significant quantity of chemicals are required to pretreat the lignocellulosic substrate, chemical pretreatment is clearly more costly. Combination pretreatments have been proven to be more successful than solo pretreatments, and there is a wide range of combinations that may be used in the future. A recent study critically examines and analyzes various pretreatment techniques, biomass supplies, chemical makeup of various agricultural biomass, and its application for bioenergy production. Various bioHydrogen, bioMethane, bioEthanol, bioMethanol, bioButanol, and bioDiesel pretreatment methods are also addressed**.**

KEYWORDS- Bio-butanol, Bio-ethanol, Bio-hydrogen, Bio-methanol, Lignocellulosic materials**.**

I. INTRODUCTION

Due to the negative consequences of utilizing vestige petroleum like coal, oil, natural gas, etc., such as the green-house consequence and global-warming, economic growth across the world has lately necessitated the need for alternative energy supplies [1]. Excessive use of vestige-fuels, principally in metropolitan expanses, has ensued in increasing pollution in recent times. As a result, there are significant quantities of green-house-gas (GHG) emissions in global warming, the atmosphere, price increases, and unanticipated environmental changes [2]. All of these flaws in fossil fuels, as well as their hurried exhaustion, have bolstered the notion of alternate, renewable, supportable, and inexpensive vitality foundations like biofuels, such as bio Hydrogen, bio Methane, bioethanol, bioethanol, and bio Butanol. The rapid growth of the populace of humans is supplemented by the production of enormous quantities of various kinds of garbage, necessitating the immediate solution to the waste disposal issue [3]. Energy investment in trash disposal is not cost effective, but waste use for energy generation is. For sustainable energy development, there is increasing Plant-based fuels and organic biodegradable wastes have sparked interest in their production and application. It also contributes to the environ-mentally sustainable growth of the economy and society. In the near run, biomass is the merely renewable and appropriate principal vitality supply that can offer a variety of alternative transportation fuels [4].

We live in a technological era, and advancements in technology have resulted in the creation of a variety of resources and techniques for pre-treatment and manufacture of bio-fuels from lingo-cellulosic bio-mass. Pre-treatment technologies have progressed in lockstep with the advancement of bio-fuel construction techniques [5]. A variety of changes were made to car appliances to allow for the use of bio-fuels such as bio-Ethanol and bio-Diesel, which may be blended with gasoline and increase efficiency. Biohydrogen may potentially be used to power cars, however there are many issues with biohydrogen storage and delivery. For the preparation of various types of biomass, many pretreatment techniques have been tried; however the majority of biochemical pre-treatment systems required an unnecessary quantity of costly substances. Corporeal pre-treatment requires a large quantity of energy, limiting its practicality and cost effectiveness. Many novel biofuel technologies now being researched are still restricted to laboratory measure construction, and there is a need to create methods that are practical, cost efficient, and readily commercialized [6].

The motivation for this review came from a review of the nonfiction for the grounding of a Ph.D. rundown, which revealed that several researchers used a variety of pretreatment methods, the majority of which resulted in environmental contamination because of the significant amount of substances used throughout the pretreatment This critique is critical examines various lignocellulosic bio-masses utilized in current centuries, their composition, biofuel generation from diverse biomasses, and a comparison of various bio-mass pre-treatment methods and their impact on bio-fuel produces [7].

II. DISCUSSION

A. Biofuels and Biofuels' Importance

Bio-fuels are biological gasses that are produced from agronomic bio-mass using modern bio-logical progressions and may be utilized to generate thermal energy via combustion or other technologies [8]. Biofuels now account for around 1.5 percent of worldwide transportation fuel, according to the International Energy Agency (IEA), thanks to significant growth in production over the past decade. Biofuel production has recently been favored to decrease GHGs and waste disposal since bio-fuels are bright, low carbon, great dynamism generating, inexpensive, and low-pollution creating causes [9].

1) Bio-mass to Bio-fuels

In 2012, worldwide firewood usage was projected to be nearby 89 million containers each day, with approximately half of it going to gasoline manufacturing. At current pace of use, fossil fuel supplies are expected to run out in the ensuing 50 years [10]. Bio-fuels are a viable resolution to the current problem later they are made from biomass resources that are renewable. Bio-fuels are divided into three groupings: first-Generation, second-Generation, and third-Generation bio-fuels, with fourth-generation biofuels relying on new synthetic biology techniques and are still in the early stages of development. Agricultural crops [9] such as sugar-cane, sugar-beet, wheat, rice, soybean-oil, sun-flower and palm-oil, among others) are used to make first-Generation biofuels, and the technology for converting crops to biofuels is well-developed. The debate over whether to use crops for food or biofuel is known as the "Food vs. Energy" dispute [11]. As a result, scientists choose to make second and third generation biofuels from non-Food produces, grasslands, cultivated and food-wastes, algae, and other sources. The development of second-generation biofuels is primarily focused on the development of bio-fuels through renewable energy resources, which might help reduce fossil fuel usage and CO2 [12] emissions, hence preventing global climate change on our Earth. As a consequence, using biomass resources is one of the most effective strategies to conserve our ecosystem in the twenty-first century.

Municipal-solid-wastes, spent cooking-oil, industrial-wastes, agricultural wastes, and sewage-sludge are samples of wastelands that may be utilized to produce second-Generation biofuels. They may be used to make Bio-Diesel, bio-Ethanol, bio-Methanol; bio-Butanol, bio-Gas, and bio-Hydrogen are examples of biofuels. The majority of 3rd-generation bio-fuels are made from algal feed-stock. One of the most important renewable energy sources is bio-Ethanol and it may be made from algal feedstock [13]. The 4^{th} generation bio-fuels, which primarily consist of photo-biological solar-fuels and electro Fuels, are anticipated to make significant advances in the area of bio-fuels. The construction of these astral bio-Fuels is a new field-technology that relies on the through alteration of solar-energy into petroleum using limitless, inexpensive, and readily accessible raw materials. Biofuels of the $I^{st,}$ II^{nd} and III^{rd} generations are made from bio-mass, however biofuels of the IV^{th} generation are made from algae and cyanobacteria using synthetic biology. II^{nd} and III^{rd} age group bio-fuels, which are made from agricultural wastes and algal biomass, have been shown to be more beneficial than first and second generation biofuels [14]. Algal bio-mass is added common in environment, and it is mostly grown in a variety of waste-water springs.

2) Agriculture Biomass and Biomass Resources

Bio-fuels may be ended from a broad range of bio-mass springs. On a dry weight basis, yearly worldwide primary biomass output is about 220 billion tonnes, equating to 4500.00 EJ of solar-energy absorbed separately year. On a long-term basis, a 270 EJ annual bioenergy market may be generated from this biomass. Woods and wood-wastes, farming collects and surplus by-products, MSW, animal-wastes, food-processing-wastes, aquatic-plants, and algae are some of the other bio-mass incomes. Wood and wood wastes generate the most biomass energy (64.00%), tracked by MSW (24.00%), farming-waste (5.00%), and land-fill vapors (5.00%) [15]. Poplar, willow, and eucalyptus are fast-growing plants that may be gathered each rare age. With short-rotation poplar copses grownup in 3 7-year gyrations on ordinary or excellent soil, it is feasible to collect 10–13 t of arid staple bio-mass per hectare each year. Bark, sawdust, board ends, and other wood waste from forest goods sector are often utilized for energy generation. Biomass production has the potential to be a valuable source for 3rd biofuels like bio-diesel [16].

Farming bio-mass is a wide class of bio-mass that encompasses both food Based and non-food-based components of crops like plants, debris, cob of maize stover, plantation appurtenances, rice-straw, rice-husk etc., perpetual grasslands, and visceral wastelands [17]. Cellulosic wildernesses include achene wastes (pulp-mill-rejects). In terms of absolute agricultural production and per capita income, output, the Wheat, Maize, Rice, and Sugarcane are the top four primary crops, which generate the bulk of lignocellulosic biomass in the agricultural sector. The projected global yearly output of main agricultural crop-based bio-mass is shown in Table 1. Every year, these four main crops produce 5358.540 million tons of dehydrated bio-mass. Although the majority of it is used as animal feed, a large portion of it is burned on fields [18].

Table 1: Estimated World Annual Biomass Production from Major Agricultural Crops

Crop	Total cultivated area (million hectare)	Total grain yield (million tons)	Average grain to aerial biomass ratio	Total estimated dry biomass (million tons)
Maize	159.531	817.110	0.30	2723.70
Wheat	225.437	681.915	1.0	681.92
Rice	161.420	678.688	0.75	904.92
Sugarcane	26.2	–	40 t	1048.00

3) Agricultural Waste Chemical Composition

Agricultural-wastes include Cellulose, Hemi-cellulose, Lignin, Protein, and Ash, among other things. Table 2 shows the chemical makeup of key agricultural crops. Lignocellulose is a compound Carbo-Hydrate Polymer made up of Cellulose, Hemicellulose, and Lignin that makes up the majority of agricultural waste. In lignocellulose, the percentage arrangement of Cellulose, Hemi-cellulose, Lignin, and Others is 35.00% to 50.00%, 20.00% to 35.00%, 15.00% to 20.00%, and 15.00% to 20.00%, respectively [19].

Table 2: Cellulose, Hemicellulose and Contents in Common Agricultural Biomass

Lignocellulose biomass	Cellulose (%)	Hemicellulose (%)	Lignin (%)
Corn cobs	33.6	37.2	19.3
Cotton seed hairs	80–95	5–20	0
Oat straw	39.4	27.1	20.7
Grasses	25–40	35–50	10–30
Hardwood stems	40–55	24–40	18–25
Leaves	15–20	80–85	0
Newspaper	40–55	25–40	18–30
Nut shells	25–30	25–30	30–40
Wheat straw	30,39.2	50,26.1	15,21.1
Maize stover	37.5	30	10.3
Rice straw	44.3	35.5	20.4
Rice husk	34.4	29.3	19.2
Corn straw	42.6	21.3	10–20
Sugarcane bagasse	45	20	30

B. Lignocellulosic Bio-mass Bio-fuels

1) Bio-Hydrogen

The only by-product created when bio-hydrogen is often used as a fueling in fusion reactors or combustion engines is rainwater, which is carbon-free and so does not pollute the environment, it is the cheapest and greenest biofuel for the future [20]. Bio-hydrogen is a non-toxic, colorless, invisible, and cloud of gas that has the able to manufacture more electricity than any other fuel. It is non-toxic, translucent, odorless, and unscented, with a heat of combustion of 143 GJ/ton. One of three techniques for producing bio-hydrogen is bio-photolysis of freshwater, photo-fermentation, or dark fermenting. Water plant is a two-step process that involves a preferentially necessarily related component and series of pictures active microorganisms such as cyanobacteria and green microalgae [21]. Photo Fermentation is the decomposition of an organic substrate into bio-hydrogen by a micro-organisms variety of photo-synthetic microbes via a sequence of bio-chemical processes comprising 3 stages, anaerobic conversion is analogous to this. Because Photo-Fermentation happens in the presence of light, it differs from dark fermentation. Acidogenesis (creation of CH3COOH + H2) occurs in dark fermentation, and the hydrogen generated through acid-ogenesis is used in methan-ogenesis to produce CH4 [22] and CO_2. It is necessary to reduce hydrogen consumption (or methane production) in order to get a high yield of hydrogen. Bio-hydrogen may be made from waste disposal, end up wasting sludge, bioethanol production wastes, and industrial byproducts. For bio-hydrogen generation, a wide variety of lignocellulosic wastes have been utilized.

Heating lingo-cellulosic bio-mass with an alkaline or acid pretreatment has been shown to be beneficial for the generation of bio-hydrogen. H2SO4 is the most common acid, while NaOH is the most frequent alkali. Pretreatment requires heating, and a pH of 5.5–6.5 is ideal for biohydrogen generation. Biohydrogen production were greater after ultrasonic treatments. If the various microorganisms employed are in symbiosis, co-culture of microorganisms may also enhance biohydrogen generation.

2) Bio-Ethanol

Bio-Ethanol is now the most prevalent bio-fuel, and it is mostly generated industrially from maize and sugarcane. In 2010, global ethanol output rose to more than 85.6 billion liters [23]. Ethanol may be mixed with gasoline to decrease greenhouse gas emissions, unburned hydrocarbons, and toxins. It may also decrease Sulphur dioxide emissions, which are the primary source of acid rain. Bioethanol synthesis from wastes and agricultural byproducts such hardwood foundation, maize hammer and metallurgy, maize stock, soybeans garbage, agricultural residues, orange peels, leaves, among filaments has a lot of promise.

As can be seen, pre-treatments with aqueous acid and alkali are commonly used for bio-Ethanol production. After pre-treating biomass with auto-hydrolysis, the highest bioethanol yield (84.00%) was obtained i.e. steam-explosion. Acid pretreatment of lingo-cellulosic bio-mass has been demonstrated to be more successful than heat pretreatment because it transforms the hemicellulose part of the biomass into reducible sugars.

3) Bio-Methane

Bio-methane, which is fashioned during anaerobic absorption of the substrate and has a high energy value, is another very promising biofuel for future prospects. Hydrogen production from a variety of biochemical or woody biomass wastes is considered desirable due to its financial and environmental benefits. In terms of fuel consumption output/input ratio, methane synthesis via biogas production has been the most efficient means of handling overall energy creation from biomass compared to all other techniques of electricity production through physiological and temperature dependent channels of conversion processes (28.8 MJ/MJ) [24]. It can be inferred that, among the different kinds of substrate pre-treatments utilized for bio-methane generation, alkali pre-treatment (NaOH) is the most often employed. Microalgal bio-mass are excellent substrates for bio-methane synthesis, according to the literature.

If the yield is less than 25% of the feedstock, saleable construction of butanol is still uneconomical. However, butanol's fuel qualities are supplementary appealing than ethanols. Butanol may be secondhand as a fuel in interior ignition engines. It is more comparable to gasoline than ethanol because of its longer hydrocarbon chain, which makes it non-polar. Butanol has been shown to operate without modification in cars intended to run on gasoline. Because of the economic and environmental benefits, hydrogen synthesis from a range of biochemistry or hardwood biomass residues is deemed beneficial. Methane polymerization via anaerobic digestion process has always been the most excellent mechanism of handling total electricity creation from organic matter in terms of fuel consuming output/input ratio, particularly in comparison to all of the other strategies of power production through neurobiological and temperature completely reliant touchpoints of energy conversion. Despite the development of numerous bioprocessing technologies for preprocessing, enzymatic hydrolysis, and fermented, bio-alcohol manufacture from lignocelluloses remains limited owing to cost. The development and deployment of robust p -solubilizing and bio-alcohol-producing microorganisms in a centralized previously described system could overcome this cost restriction. Butanol is used in moisturizers, hydraulic fluids, detergents formulations, medications, antidepressants, pheromones, and micronutrients, and even a chemical middleman in the manufacturing of butyl monomer and monomer. It's also used in the pharmaceutical sector as an extracting solvent. Solu-bilization is the most effective of several substrates alkaline pretreatment being used bio-butanol production.

4) Bio-Diesel

Bio-diesel is another potential bio-fuel, and microalgal biotechnology may produce high latent biodiesel from microalgae. Algal biomass may be readily produced; under favorable circumstances, algae grow quickly and store approximately half of their entire weight in oil. Thousands of algae species exist in nature, ranging in size from microscopic to 60 meters. In recent years, a significant variety of algae species i.e. Chlorella, Chlamy-domonas, Mis-canthus, Nanno-chloropsis, and others) have been utilized to produce bio-fuel. Oil and starch from algae may be turned into biofuels including bio-gas, bioethanol, and biodiesel. Algal triglycerides are trans-esterified using an alkali compound to produce bio-Diesel. Because of its organization to satisfy future challenges as a result of vast quantities, increased production and economic rates, no need to grow on farm production, high suitability for power generation of gaseous and liquid biofuels, and indeed the way to generate a variety of price products in bio refining, biomass energy has more appeal for cellulosic ethanol than other biomass resources. A unique approach for extracting co2 from the atmosphere of CO2 has recently been developed using microalga biomass. Table 3 lists some of the biomasses utilized in biodiesel manufacturing.

Table 3: Pretreatments of Feedstock Used for Bio-Diesel Production

Algae used	Pretreatment used	Bio-diesel yield
Cladophora sp., *Oedogonium* sp., and *Spirogyra* sp.	Alkali catalysed transesterification	Maximum for *Cladophora* sp.
Macroalgal biomass	-	18.6% of lipid
***Cassia fistula* L. fruit pulp**	*Rhodosporidium kratochvilovae* HIMPA1	High saturated fatty acids content 72.58%
***Aspergillus candidus* IBBG4 grown on untreated banana peels and sugarcane bagasse**	Direct in situ acid esterification	420 mg/L and 400 mg/L for banana peel and sugarcane bagasse respectively

C. Lignocellulosic Biomass Pretreatment

Lignocellulosic biomass is made up of cellulose, lignocellulose, and lignin. Thiosulfate of lignocellulosic biomass is the process of breaking down complex lignocellulose into simpler molecules like cellulose, lignocellulose, and lignin. The lignin is eventually removed, the hemicellulose is maintained, the cellulose crystalline structure is decreased, and the substance's porosity is raised. A cost-effective pretreatment approach should improve sugar synthesis in the subsequent enzymatic hydrolysis phase, reducing carbohydrate weakening and the establishment of breakdown and fermentation inhibitors.

III. CONCLUSION

The researchers were motivated by the availability of lignocellulosic trash to utilize this low-cost foundation for bio-fuel construction. Lignocellulosic excess is becoming more popular as a foundation of fermen-table dearests for the manufacture of liquid fuels. Enzymatic handling of lignocellulosic biomass after pre-treatment is further costly, which is why many researches are being conducted to find a solution to this issue. It is also essential to use trash for the production of biofuel without the use of costly chemicals in order to discover the optimum pretreatment technique. In general, there are four kinds of pretreatment methods: physical, chemical, physicochemical, and biological. All of these techniques have disadvantages or downsides, and no one method can be utilized to process all kinds of biomass. As a result, it is necessary to comprehend diverse pretreatment methods, varied biomass structure and composition, as well as the connection between agricultural feedstock composition and pretreatment and their pre-treatment rendering to diverse compositions. Coalescing dual or more pre-treatment techniques has increased produces, but it has certain disadvantages, such as being more energy demanding than single pretreatment. Because the majority of hemi-cellulose is solubilized with fractional removal of lignin, watery acid pre-treatment looks to be more appropriate for different kinds of bio-mass than single pretreatment techniques. AFExp is further suited to agronomic litters, while LHW is better suited to low-lignin biomass. AFExp improves bio-mass dige-stibility by redistributing lignin and hemi-celluloses and increasing the biomass's available exterior extent. The cost-effectiveness and environmental friendliness of using lignocellulosic biomass for biofuel production has been discovered. Lignocellulosic biomass seems to be a viable substrate in light of the development and need for IInd peers biofuel construction.

However, because lignocellulosic biomass isn't always available, we can't rely on just second-generation biofuel (available in abundance on harvesting time). A balance amongst fossil energy, 1st renewables, and 2nd bio products must be maintained to fulfil our future energy demands. Finding a new market will help to make the construction of second-generation biofuels more cost-effective. The usage of 2nd biofuel inside this airline industry aviation industry may pave the way for a new, ecologically friendly business. This systematic review will aid in the identification of the best pretreatment method for the each lignocellulosic biomass. It would also provide clear information on various permutations of pretreatment procedures.

REFERENCES

[1] H. Kumar, A. K. Sarma, and P. Kumar, “Experimental investigation of 2-EHN effects upon CI engine attributes fuelled with used cooking oil-based hybrid microemulsion biofuel,” Int. J. Environ. Sci. Technol., 2021.

[2] I. Ballesteros, M. J. Negro, J. M. Oliva, A. Cabañas, P. Manzanares, and M. Ballesteros, “Ethanol Production From Steam-Explosion Pretreated Wheat Straw,” in Twenty-Seventh Symposium on Biotechnology for Fuels and Chemicals, 2007.

[3] R. K. Varshney, M. K. Prasad, and M. Garg, “Comparison of nitroglycerin versus lignocaine spray to attenuate haemodynamic changes in elective surgical patients undergoing direct laryngoscopy and endotracheal intubation a prospective randomised study,” Sultan Qaboos Univ. Med. J., 2019.

[4] L. Raslavičius, N. Striūgas, and M. Felneris, “New insights into algae factories of the future,” Renewable and Sustainable Energy Reviews. 2018.

[5] M. Agarwal and D. Dhruvakumar, “Coronally Repositioned Flap with Bioresorbable Collagen Membrane for Miller’s Class i and II Recession Defects: A Case Series,” Med. Princ. Pract., 2019.

[6] A. Almodares and M. R. Hadi, “Production of bioethanol from sweet sorghum: A review,” African J. Agric. Res., 2009.

[7] S. Gupta et al., “Coelogin ameliorates metabolic dyshomeostasis by regulating adipogenesis and enhancing energy expenditure in adipose tissue,” Pharmacol. Res., 2021.

[8] Sustainable Production of Second-Generation Biofuels. 2010.

[9] R. K. Pareek, K. Singh, and R. Ram, “Sequestration of heavy metals from petroleum refinery effluent by active carbon adsorbents precursor to rice husk and sugarcane bagasse,” Ann. Biol., 2021.

[10] Y. Arifin, E. Tanudjaja, A. Dimyati, and R. Pinontoan, “A second generation biofuel from cellulosic agricultural by-product fermentation using clostridium species for electricity generation,” in Energy Procedia, 2014.

[11] S. P. Singh, A. Pundhir, and S. Ghosh, “Validation of an analytical methodology for determination of tetracyclines residues in honey by UPLC-MS/MS detection,” Indian J. Nat. Prod. Resour., 2015.

[12] R. S. Rajaura et al., “Structural and surface modification of carbon nanotubes for enhanced hydrogen storage density,” Nano-Structures and Nano-Objects, 2018.

[13] J. K. Virk, A. N. Kalia, V. K. Gauttam, M. Mukhija, and G. Rath, “Development and characterization of spheroidal antidiabetic polyherbal formulation from fresh vegetable juice: A novel approach,” J. Food Biochem., 2021.

[14] D. W. Wilson et al., “Perspectives of Human development: Time, Space, and Chrononutrition,” Open Nutraceuticals J., 2012.

[15] A. Demirbas, T. Ozturk, and M. F. Demirbas, “Recovery of energy and chemicals from carbonaceous materials,” Energy Sources, Part A Recover. Util. Environ. Eff., 2006.

[16] M. H. Salmani, S. Rehman, K. Zaidi, and A. K. Hasan, “Study of ignition characteristics of microemulsion of coconut oil under off diesel engine conditions,” Eng. Sci. Technol. an Int. J., 2015.

[17] A. Demirbaş, “Energy balance, energy sources, energy policy, future developments and energy investments in Turkey,” Energy Convers. Manag., 2001.

[18] A. Mittal, A. Maiti, and K. K. Jha, “Formulation, evaluation and optimization of diclofenac potassium micropellets using 32 full factorial design,” Russ. J. Biopharm., 2014.

[19] A. Chaudhary, N. Tiwari, V. Jain, and R. Singh, “Microporous bilayer osmotic tablet for colon-specific delivery,” Eur. J. Pharm. Biopharm., 2011.

[20] M. Ghiasian, “Biophotolysis-Based Hydrogen Production by Cyanobacteria,” 2019.

[21] P. T. Sekoai and E. B. Gueguim Kana, “A two-stage modelling and optimization of biohydrogen production from a mixture of agro-municipal waste,” Int. J. Hydrogen Energy, 2013.

[22] E. G. Nisbet et al., “Very Strong Atmospheric Methane Growth in the 4 Years 2014–2017: Implications for the Paris Agreement,” Global Biogeochem. Cycles, 2019.

[23] P. S. Nigam and A. Singh, “Production of liquid biofuels from renewable resources,” Progress in Energy and Combustion Science. 2011.

[24] M. N. Siddiquee and S. Rohani, “Lipid extraction and biodiesel production from municipal sewage sludges: A review,” Renewable and Sustainable Energy Reviews. 2011.