Production and Sampling of Biofuel Extracted from Algae

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Abstract— Biodiesel has received much attention in recent years. There are various methods are available for production of biodiesel from vegetable oils but the production of biodiesel from micro algae is a newly emerging field. The attention is focused to develop biodiesel from green algae and evaluate its effect on the engine combustion, performance and emission. Algae were found to be suitable for biodiesel production on a large scale. Three methods are available for growing algae, by photo-bio-reactor, open race way pond and hybrid system. Then oil is extracted from these algae by different process. By use of various types of homogeneous and heterogeneous catalyzed transesterification reaction biodiesel will be produced. Then these biofuel will blended in proportions of 5%, 10%, 15% and 20% by weight with standard commercial diesel in different proportion by volume and their properties were compared. This work attempts to find a suitable algal fuel and optimum blending levels with diesel to address the combustion, performance and emission parameter of an engine.

Key words: Microalgae, Biodiesel, Open race way pond, Transesterification

I. INTRODUCTION

With a rapid increase in the demand of fossil fuel, decrease in the availability of crude oil supplies and greater environmental stringent norms on pollution has created enormous interest in researchers in formulating and testing biofuels in recent times. The most promising method for deriving biodiesel from renewable energy source is transesterification process. Many vegetables plants were found successful in the production of biodiesel like Neem, Jatropha, Karanja, Cotton seed, Rapeseed, Soyabean, etc. It has also been reported in the literature that the use of biodiesel considerably reduced emission and increased the performance of engine (Agarwal *et al.* 2001, 2007). Many researchers have reported on the possibility for production of biodiesel from algae. Algal growth is photosynthetic in nature (i.e) they mainly use sunlight along with nutrients for their growth. Chlorophyll A and Chlorophyll B are the main components which undergo metabolic activities. Algae have a capability of fixing atmospheric carbon di-oxide and can be grown in intensive culture on a non-arable land.

Based on the above said limitations of Jatropha, an alternative feed stock for the generation of biodiesel is necessary. In the case microalgae is considered as the feed stock. Microalgae are a diverse group of prokaryotic and eukaryotic photosynthetic microorganism which grows rapidly due to their simple structure. Microalgae have been investigated for the production of biodiesel, bio-oil, bio-Syngas and bio-hydrogen. It was estimated to be more than 2,00,000 species of microalgae which are capable of producing lipids. On-going advances in cultivation techniques coupled with genetic of crucial metabolic networks will further enhance microalgae as an attractive platform for the production of numerous high value compounds. Microalgae with lipid content upto 60% grown in saline or sea water have the potential to be the source of biodiesel.

A. *Biodiesel:*

Biodiesel is typically produced by reacting a vegetable oil or animal fat with methanol or ethanol in the presence of a catalyst to yield methyl or ethyl esters (biodiesel) and glycerin . The purpose of the transesterification process is to lower the viscosity and oxygen content of the vegetable oil. In this process, an alcohol (e.g., methanol, ethanol, butanol) is reacted with the vegetable oil (fatty acid) in the presence of an alkali catalyst (e.g., KOH, NaOH) to produce biodiesel and glycerol. Being immiscible, biodiesel is easily separated from glycerol. Transesterification is an inexpensive way of transforming the large, branched molecular structure of the vegetable oils into smaller, straight-chain molecules of the type required in regular diesel combustion engines. Generally, methanol is preferred for transesterification, because it is less expensive than ethanol. Biodiesel produces slightly lower power and torque, which results in a higher consumption than No. 2 diesel fuel for driving.

However, biodiesel is better than diesel in terms of sulfur content, flash point, aromatic content, and biodegradability. Precautions should be taken in very cold climates, where biodiesel may gel earlier than diesel upon cooling. The cost of biodiesels varies depending on the feedstock, geographic area, methanol prices, and seasonal variability in crop production .

Most of the biodiesel is currently made from soybean, rapeseed, and palm oils. The high value of soybean oil as a food product makes production of a cost-effective biodiesel very challenging. However, there are large amounts of low-cost oils and fats (e.g., restaurant waste, beef tallow, pork lard, and yellow grease) that could be converted to biodiesel. Biodiesel produces slightly lower power and torque; hence, the fuel consumption is higher than No. 2 diesel. However, biodiesel is better than diesel in terms of sulfur content, flash point, aromatic content, and biodegradability.

II. LITERATURE REVIEW

Yunjun Yan et al[1] presented Biotechnological preparation of biodiesel and its high valued derivatives: A review. Meanwhile, another strategy to reduce biodiesel production cost is the development of new technologies with better and cost-effective catalysis (transesterification), such as ultra-sonication and microwave-assisted treatment, transesterification in $SCCO_2$, improvement of transesterification efficiency by solvent engineering, and utilization of synergistically combined lipases. Thus, a novel strategy integrating biotechnology into cost-effective industrialization includes production of the cheapest and most tolerable lipases, development of better and cost-effect

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effective catalysis techniques, bio-refinement of part products of biodiesel industry into high-valued derivatives, and further exploration of cheap potential feedstock.

Ravindra Kumar, Veena Bansal, M.B. Patel, A.S. Sarpal et al[2] presented Compositional Analysis of Algal Biomass in a Nuclear Magnetic Resonance (NMR) Tube .We have explored an alternative to soxhlet extraction method which has the potential to reduced solvent consumption and decrease extraction times. A rapid methodology has been developed to find the chemical composition of algae directly in a NMR tube without long and laborious wet chemical analysis. This methodology is capable of monitoring a large number of samples with a minimal investment of time. NMR spectroscopy analysis of lipid extracts can contribute to the chemotaxonomic identification of different algal species, providing a technique for simultaneous recognition of very large number of molecular species. An additional advantage of NMR spectroscopy analysis is that it gives detailed structure specific information, while minimizing the risk of chemical modification. The application of a second dimension HSQC gives resolution for more precise structural assignments of the different classes of compounds contained in the algae samples.

Rakesh Singh Gour1, Anil Kant1 and Rajinder Singh Chauhan et al[3] presented Screening of micro algae for Growth and lipid accumulation properties .Chlorella sp. followed by Scenedesmus quadricauda and Scenedesmus dimorphus were the dominant micro algae species of the region sampled. All the isolated micro algae species grew better when urea was used as nitrogen source compared to NaNO3 in BG11 media. Scenedesmus dimorphus produced highest lipid content while Scenedesmus quadricauda being least productive. A few promising native isolates of Chlorella sp. showing the best combination of lipid content, biomass and lipid productivity under normal growth conditions were identified.

Bharat Gamia, J. P. Patelb, I.L.Kotharia et al[4] presented Cultivation of Chlorella protothecoides (ISIBES – 101) under autotrophic and heterotrophic conditions for biofuel production. Chlorella protothecoides (ISIBES – 101) can be cultivated in both autotrophic and heterotrophic condition. A cultivation type has no significant role in fatty acid composition of algae oil. Heterotrophic cultivation with fed-batch culture was more suitable for high cell density cultivation with high lipid content. Low price carbon source like maize-glucose with urea produce lipid with fatty acid composition, which is more suitable for high quality biodiesel production. Heterotophic cultivation is recommended to further cultivation in fed-batch mode.

Bio Bamba a,b, Xiaoxi Yu a,c, Paul Lozano a, Allassane Ouattara b, Maryline Abert Vian c, Yves Lozano a, et al[5] presented Photobioreactor-based procedures for reproducible small-scale production of microalgal biomasses. On a developing country level, this simple designed and low-cost PBR can be used for local microalga production in the low-level technical environments found in tropical countries. Temperature, light availability or illumination, and potent external pollution of the growing biomass, are critical microalgae production parameters to be mastered for optimising photosynthetic activity and productivity of microalgae cultures.

Amin Talebian-Kiakalaieh et al[6] presented A review on novel processes of biodiesel production from waste cooking oil. The transesterification reaction is the best method for production and modification of biodiesel. However, the cooking process has negative influences on oil properties and can create different types of impurities in the oil and can also increase the FFA and water content of oil. Therefore, these obstacles increase the catalyst is the most important property which can make them economical for industrial production in a continuous process. Hence, various methods such as membrane reactor, reactive distillation, reactive absorption, microwave, and ultrasonic to reduce production costs, reaction time, catalyst and alcohol requirements have been used in transesterification reactions. These methods can increase the quality of FAME for applications to diesel engines without any kind of engine modification.

I Rawat, R. Ranjith Kumar, T. Mutanda et al[7] presented Biodiesel from microalgae: A critical evaluation from laboratory to large scale production. Biodiesel from microalgae, some of the recovery methods being considered include filtration, centrifugation, gravity sedimentation, chemical flocculation and dissolved air flotation. With regards to commercial ventures and claims thus far, most of the companies surveyed use closed systems (52%) for microalgal cultivation with the rest being open ponds (26%) and natural settings (22%). Although mechanical pressing works well for oil seeds, currently the method of choice still involves solvent extraction. Other techniques such as supercritical fluid extraction are still being evaluated for large scale application. In situ transesterification is an emerging technology that has shown potential for processing unit and cost reduction at large scale.

Andrea Maria Rizzo, Matteo Prussi, Lorenzo Bettucci, Ilaria Marsili Libelli et al[8] presented Characterization of microalga Chlorella as a fuel and its thermogravimetric behavior. 1.2 kg of Chlorella sample S2 was processed in a batch pyrolysis reactor at 450 _C obtaining a yield of 34 wt.% pyrolysis liquid, 29 wt.% char and 37 wt.% gases (calculated by difference). Pyrolysis oil from Chlorella (upper phase) exhibits very peculiar characteristics, because it is less oxygenated (approx. oxygen content of 35 vs. 54 wt.% of conventional lignocellulosic pyrolysis oil), it has higher HHV (28.4 vs. 17.2 MJ_kg_1), lower acidity (pH 9.2 vs 2.3) and lower density (1 vs. 1.1–1.2 kg m_3), and its H/C ratio (0.18 vs. 0.19) is closer to that of conventional automotive- grade diesel (0.15). On the other hand, the water content is comparable, the ash content is markedly higher, probably due to the presence of fine char in the oil, and the nitrogen content is almost the same as the raw feedstock, which can be a limiting factor for its direct use in energy conversion systems due to NOx formation during combustion.

Maurycy Daroch et al[9] presented Recent advances in liquid biofuel production from algal feedstocks. Efficient acid catalysis has been reported for many strains as well as mixed cultures using both sequential (oil extraction followed by alcoholysis) and in situ transesterification. The major drawback of this method is the requirement for methanol to drive the reaction forward; that impacts cost effectiveness, sustainability and applicability of a coproduct, glycerol for many industries. There are few reports on the biodiesel

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synthesis with the biological catalyst lipase. This most environmentally friendly method of biofuel production has been long seen as a potential breakthrough in biodiesel production, however high catalyst cost still hinders development of lipase-catalysed biodiesel production in a large scale.

Jegan, G, S.Mukund, N.S.Senthilkumar and RamaRajaVallinayagam et al[10] presented Influence of different concentrations of sodium bicarbonate on growth rate and biochemical composition of micro algae. In summary, the findings suggest that bicarbonate addition can significantly increase photosynthetic efficiency and production of cellular compounds including pigments and lipids in microalgae, although the responses are species specific when compared under similar conditions. These findings also indicate that higher yields of valuable lipid and pigment compounds may be promoted by utilising bicarbonate addition in commercial production systems Chlorella vulgaris can be employed in large scale systems for flue gas mitigation as it has exhibited higher tolerance to increased bicarbonate levels.

Bharanidharan.M, Rama Raja Valli Nayagam.S and V Sivasubramanian et al[11] presented Mass cultivation of micro alga Chlorococcum humicola in open raceway pond and assessment of bio-fuel potential .The present study deals with growing Chlorococcum humicola in open raceway pond and utilizing the biomass feedstock for biofuel assessment. In addition extraction and estimation of various biochemicals and pigment analyses were made. The GCMS analysis of FAME showed the presence of 32 different compounds of fatty acids. The methyl esters appears to be in significant proportion of FAME indicates Chlorococcum humicola as a better biofuel candidate. Based on the results obtained, further trials have to be carried out for studying economic feasibility during the scaling up process.

Sayeda M. Abdo1, Entesar Ahmed3, Sanaa Abo El-Enin 2, Rawheya S. El Din3, Guzine El Diwani2and Gamila Ali1 et al[12] presented Growth Rate and Fatty Acids Profile of 19 Microalgal Strains Isolated from River Nile for Biodiesel Production .The total lipid content in microalgae varies greatly from one species to another although those belong to the same algal group. So, it is very important to screen microalgal strains before suitable strain can be selected for their application. Two species from 19 microalgal isolated species revealed high lipid content, these are Microcystis aeruginosa and Chlamydomonus variabills. Albeit, Anabaena spiroides revealed low lipid productivity it gives high palmitic acid (C: 16-0) conten.

Anita Kirroliaa, Narsi R. Bishnoia and Rajesh Singh et al[13] presented Effect of shaking, incubation temperature, salinity and media composition on growth traits of green microalgae Chlorococcum sp. The present study signifies that the growth of microalgae not only depends on the temperature, light and nutrient availability, but is also highly affected by the salinity and culture media composition. Higher lipid, chlorophyll and biomass content was observed when culture of Chlorococcum spp. is grown at 25 0C. The effect of various concentrations of NaCl on the isolated algal species of Chlorococcum spp. showed, increased biomass yield at 0.2mM NaCl concentration as compared to control and then it subsequently decreases with increase in NaCl concentration. Initial increase of NaCl concentration from 0.0-0.2 mM decreased the lipid accumulation from 17.26 to 16.09 % dcw. The effect of culture media composition showed that BG-11 and BBM are the best suited media for the growth of this species.

Neelam Arun and D.P. Singh et al[14] presented Microalgae: The Future Fuel (Review) .Microalgae appear to represent the only current renewable way to generate biofuels. Microalgae biofuels are also likely to have a much lower impact on the environment and on the world's food supply than conventional biofuel-producing crops. When compared with plants biofuel, microalgal biomass has a high caloric value, low viscosity and low density, properties that make microalgae more suitable for biofuel than lignocellulosic materials , as well as due their inherently high-lipid content, semi-steady-state production, and suitability in a variety of climates.

Ugoala, Emeka et al[15] presented Constraints to large scale algae biomass production and utilization .While the technology for large scale algal biofuel production is not yet commercially viable, algal production systems may contribute to rural development, not only through their multiple environmental benefits but also through their contribution of diversification to integrated systems by efficiently co-producing energy with valuable nutrients, animal feed, fertilizers, biofuels and other products that can be customized on the basis of the local needs.

Razif Harun et al[16] presented Exploring alkaline pre-treatment of microalgal biomass for bioethanol production. NaOH was used to treat C. infusionum at varying temperatures and durations. The maximum bioethanol yield obtained was 26.1% g ethanol/g algae for alkaline pre-treatment under 0.75% (w/v) NaOH and 120 _C for 30 min. With the high level of glucose released, there exist a potential opportunity for the use of alkaline pre-treatment in the production of bioethanol from microalgae.

Rawat, R. Ranjith Kumar, T. Mutand et al[17] presented Dual role of microalgae: Phycoremediation of domestic wastewater and biomass production for sustainable biofuels production. Microalgae have contributed to tertiary treatment in conventional wastewater treatment and more directly to BOD and nutrient removal in engineered systems such as high rate algal ponds. More recently research has focused on exploiting final wastewater\ streams that have residual nutrients such as nitrogen and phosphorus as a resource to harvest microalgae rather than a waste product. Providing optimum conditions promotes improved lipid production. Therefore the biomass provides dual benefits of wastewater treatment and oil production. The lipid is then transesterified in FAME which is used as biodiesel.

Belinda S.M. Sturm et al[18] presented An energy evaluation of coupling nutrient removal from wastewater with algal biomass production. The energy content of algal biomass was also considered as an alternate to lipid extraction and biodiesel production. Direct combustion of algal biomass may be a more viable energy source than biofuel production, especially when the lipid content of dry biomass (10% in this field experiment) is lower than the high values reported in lab-scale reactors (50–60%). In addition to nutrient removal, there are several processes in

WWTP that can be coupled to algal biomass production to improve the energy balance, and to lessen the environmental footprint of WWTP, particularly CO2 and heat recovery from biogas combustion.

M. Fatih Demirbas et al[19] presented Biofuels from algae for sustainable development. This paper describes hydrogen production from biomass such as moss and algae by laboratory- scale tests of pyrolysis and steam-gasification. The conversion of biomass into hydrogen is interested in the viewpoint of hydrogen production from renewable resource. The yields of hydrogen from biomass by the pyrolysis and the steam gasification increase with increasing of temperature. In general, the steam gasification temperature is higher than that of pyrolysis and the yield of hydrogen from the air–steam gasification is higher than that of the pyrolysis. Algal-oil processes into biodiesel as easily as oil derived from land-based crops.

Rocio Maceira et al[20] presented Macroalgae: Raw material for biodiesel production. Biodiesel production from oil extracted from marine algae is feasible by transesterification. Moreover, this study indicates that the oil extraction can be carried out simultaneously with the transesterification, so the product costs are cheaper. On the other hand, only in Galicia, 1000 tonnes/year of biodiesel can be produced from macroalgae. Finally, heating power has been calculated from the algae residues and their value is valid for the use of algae residues like pellets to be burnt in heating boilers. Then, the macroalgae residue is totally used. In short, it has been demonstrated that macroalgae could be used as a potential source to produce biodiesel and fuel pellets.

Kodandoor Sharathchandra and Madaiah Rajashekhar et al[21] presented Total lipid and fatty acid composition in some freshwater cyanobacteria .The study documents the lipid and fatty acid content in cyanobacteria and indicates that the total lipid content and their constituent fatty acid composition vary with their groups, location and the habitat. Some of these freshwater cyanobacteria are a source of essential fatty acids that are of commercial interest, including linoleic, and α-and γ- linolenic acids, among others. Further, some cyanobacteria serve as an important source of essential fatty acids for aquatic animals; their survival and growth rates are related to fatty acid content of the feeds. The GC analysis has indicated the presence of palmitic acid in all the species followed by linoleic acid.

GuanHua Huang et al[22] presented Biodiesel production by microalgal biotechnology. The low lipid content and low biomass that can be achieved leading to the high cost of biodiesel from microalgal oils are the bottleneck for industrial production. Heterotrophic cultivation of lipid-rich microalgae with fast pyrolysis may lead to a high yield of bio-oils on a large scale. Research in genetic engineering coupled with advanced cultivation and downstream will benefit the future development of microalgae for biodiesel production.

Toshimitsu Suzuki , Taka-o Matsui, Chiyo Ueda, and Na-oki lkenaaa et al[23] presented Liquefaction of Spirulina at 300425 93 under hydrogen gave more than 90 % of conversions and *60* % of oil yields. Addition of Fe(C0)s catalyst increased oil yield from 52.3 to 66.9 % at 350 T for *60* min in tetralin. Liquefaction in water gave oil yield as high as 78.3 % at 350 93 even under nitmgen atmosphere without the catalyst. Liquefaction in toluene gave oil fractions having high heating value of '7700-7900 *callg,* but the products containing large amount of oxygen estimated to have lower heating valueof 6200 *callg.* FT-IR and gel permeation chromatograph suggested that production of oil fractions mainly proceeded via thermal scission of polypeptide and hydrolysis with water, and further hydrocracking of C-C bond is promoted in the presence of f%(C0)5-S catalyst under hydrogen.

III. Conclusion

Depletion of fossil-fuel resources, unstable price of crude oil and other fossil fuels, and environmental concerns are the main reasons for finding a new fuel which should be environmentally friendly, cheap, widely available, and technically acceptable. Biodiesel is one of the best fuel alternatives that researchers are focused on and efforts are being made to produce it at a lower cost and with outstanding fuel properties. However, for large scale application open raceway ponds appear to be more favourable with one of the added advantages being the potential for CO_2 sequestration.The transesterification reaction is the best method for production and modification of biodiesel. Acid, alkali, or enzymatic catalyzed, and non-catalyst transesterification are different approaches that have been tried for biodiesel production.

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