BIO-FUELS ALGAE: AN ALTERNATIVE RENEWABLE ENERGY SOURCE

(A REVIEW PAPER)

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ABSTRACT

Biodiesel is an alternative fuel for conventional diesel that is made from natural plant oils, animal fats, and waste cooking oils. The different methods of producing biodiesel fuel from algae grown in raceway open and artificial automotive close circuit ponds. There is potential for large-scale production of biodiesel from algal farms in photobioreactor. Harvesting of algae followed different cleaning and separation operations, extracting the oil and converting the oil from algae to biodiesel via transesterification reactions are the primary driving force for algae to fuel technology development. This paper presents an updated technology of the production and different optimize conditions that could have a profound effect on the success of this important alternative fuel production process.

KEYWORDS: Renewable Sources Energy, Bioreactor, Transesterification & Bio Fuels

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INTRODUCTION

Biomass is widely considered to be a major potential bio-fuel and renewable resource for the future. Over the last two decades, a special attention has been paid to the conversion of residual biomass and renewable materials into bio-fuels. The main advantages using this biofuel are its reliability, better quality exhaust gas emissions, its biodegradability and, it does not contribute to a net rise in the level of CO₂ in the atmosphere, and consequently to the green-house effect.

Biofuels can be defined as liquid fuels produced from biomass and organic oil for those large commercial producers mainly use seed oils such as soybean, palm, corn oils, and rapeseed. However, biodiesel produced from seed oil diverts from the food supply and the increasing competition for seed causes the oil and resulting biodiesel to become increasingly expensive [Chisti, 2008, 2013].

Algae Biofuel research is now one of the top notch research topics, mainly in the context of rising petrofuel prices and climatic changes. Algae have a usually fast growth rate in comparison to terrestrial energy

crops and additionally a significant percentage of their weight is comprised of oil. This algae oil resulting from extraction can directly be converted into biodiesel, which is renewable and an environmentally friendly biofuel. Theoretically algae offers strong contention as a promising feedstock for biodiesel production [G. Antolin, et. al., 2002]. Algae has been proposed to be the only source of renewable biodiesel that is capable of meeting the global demand for transportation fuels [Q. Hu, H. Guterman, et. al., 1996].

ALGAE

The Algae is an informal term for a large, diverse group of eukaryotes. Algae is a simple plant, mostly live in water. Algae can grow with Photosynthetic activities. It captures light energy and convert inorganic to organic matter. It's a nonvascular and use lipids and oils to help float in water. Its range of unicellular genera (Chlorella, Diatoms) to multicellular forms (giant kelp, large brown algae). Algae can provide a variety of fuels, which are diversified, versatility in nature and having high efficiency. Microalgae known as single celled algae are habitually grown in open ponds or in enclosed systems known as photo bioreactors.

Algae has a many benefits as a fuel like among all the fastest growing plants about 50% of their weight is oil, produces large amounts oil (contain oil from 15% to 70% of its dry weight) and having a high growth rate and easy to grow, contains no sulfur, no toxic, highly Biodegradable and yield of Algae is quite high in comparison of other conventional crops grown for the same purpose.

Over 40,000 species of algae have been identified, likely hundreds of thousands more to be discovered. Figure. 1 shows the biofuel production from algae.

Figure 1: Bio Fuel Production from Algae

ALGAE CULTIVATION

Growth of Algae much faster and can produce hundreds of times more oil per unit area than conventional crops such as rapeseed, palms, soybeans, or Jatropha. Algae has a harvesting cycle of 1–10 days. Algal Production or Algae Cultivation naturally and artificially are discussed below

Open Pond System, algae is cultivated in the open air. Mostly uses environmental carbon dioxide. The ponds can be in planned or unplanned, natural or artificial. Most efficient and low cost method where surface water bodies are

available with the plenty amount of water. Most popular methods in an open pond system are raceway pond. A raceway pond is a shallow artificial pond used in the cultivation of algae. The pond is divided into a rectangular grid. Each rectangle containing one channel in the shape of an oval, like an automotive raceway circuit. Each rectangle contains a paddle wheel to make the water flow continuously around the circuit.

The absence of air Closed loop systems which avoid the problem of contamination by other organisms blown in the air the most popular method in a closed-loop system is Photo bioreactors.

Photo bio-reactors are a directors that utilizes a light source to cultivate phototrophic micro-organisms.

Different types of Photo directors are available like tubular photodirector, foil photo bioreactor, plate photobioreactor, horizontal photobioreactor and Christmas tree photobioreactor. It's made up of Plastic or borosilicate glass tubes that are exposed to sunlight. Provides carefully controlled artificial environment and specific conditions for algae.

ALGAE HARVESTING

Most common harvesting methods for algal biomass include sedimentation, filtration, centrifugation, ultra-filtration or a combination of flocculation- flotation [M. E. Grima, et. al., 2003]. The various algal harvesting techniques are discussed in Table 1.

Table 1: Algae Harvesting Techniques

S. No.	Algae harvest method	Relative cost	Algal species
1	Foam fractionation	Very high	<i>Scenedesmus, Chlorella</i>
2	Centrifugation	Very high	<i>Scenedesmus, Chlorella</i>
3	Polyelectrolyte flocculation	High	<i>Dunaliella</i>
4	Filtration	High	<i>Spirulina, Coelastrum</i>
5	Microstrainers	Unknown	<i>Spirulina</i>
6	Tube settling	Low	<i>Micractinium</i>
7	Diecrete sedimentation	Low	<i>Coelastrum</i>
8	Phototactic autoconcentration	Very low	<i>Euglena, Dunaliella</i>
9	Autoflocculation	NA	<i>Micractinium</i>
10	Bioflocculation	NA	<i>Micractinium</i>

DRYING OF ALGAE

Harvested algae contain 97-99% of water. Removal of most of the water is necessary for long term storage of the algae feedstock and is required for many downstream processes. To keep algae from prolonged microbial growth, the moisture level of the harvested algae should be kept below 7%. Drying is an energy intensive process and can account for up to 30% of the total production costs. Natural drying (solar and wind) is the most economical way; however, its weather dependent nature could easily put the operation at risk of spoilage. It also requires a large space.

BIODIESEL FROM ALGAE OIL

Extracting the oil and converting the oil from algae to biodiesel is the primary driving force for algae to fuel technology development. The oil extracted can be converted to biodiesel via a transesterification reaction. Extraction of oil from algal biomass has proven to be difficult and expensive. For choosing the right extraction method for the large scale recovery of algal oil from the cells certain parameters have to be considered like the ease with which the cells disrupt, the

cost of method and the speed of the extraction method applied, etc. Some of the more promising extraction methods are bead Mills, presses, solvent extraction and less Known Methods.

Algal oil is highly viscous, with viscosities ranging 10–20 times those of Diesel fuel. The high viscosity is due to the large molecular mass and chemical structure of oils which in turn leads to problems in pumping, combustion and atomization in the injector systems of a diesel engine. Therefore, a reduction in viscosity is important to make high-viscosity oil a suitable alternative fuel for diesel engines. One of the most common methods used to reduce oil viscosity in the Biodiesel industry is called transesterification. It involves chemical conversion of the oil into its corresponding fatty ester.

Transesterification is the process of converting vegetable & plant oils into biodiesel fuel is called transesterification” and is fortunately much less complex than it sounds. Transesterification refers to a reaction between an ester of one alcohol and a second alcohol to form an ester of the second alcohol and an alcohol from the original ester, as that of methyl acetate and ethyl alcohol to form ethyl acetate and methyl alcohol. Chemically, transesterification means taking a triglyceride molecule or a complex fatty acid, neutralizing the free fatty acids, removing the glycerin and creating an alcohol ester. Glycerin is left on the bottom and methyl esters, or biodiesel, is left on top. The glycerin can be used to make soap (or any one of 1600 other products) and the methyl esters are washed and filtered.

Figure 2: Transesterification Process

The end products of this reaction are hence biodiesel and glycerol. This end-mixture is separated as follows: Ether and salt water are added to the mixture and mixed well. After some time, the entire mixture would have separated into two layers, with the bottom layer containing a mixture of ether and biodiesel. This layer is separated. Biodiesel is in turn separated from ether by a vaporizer under a high vacuum. As the ether vaporizes first, the Biodiesel will remain. The comparison of different properties of diesel and biodiesel mentions in Table 2. [M. Ahmad, et. al., 2009 & H. J. Berchmans, et. al., 2008]

Table 2: Comparison of Different Properties of Diesel and Biodiesel.

Properties	Fuel	
	Biodiesel	Diesel
Density at 15°C (g/cm ³)	0.834	0.8834
Viscosity at 40°C (mm ² /s)	2.83	4.47
Carbon, %	86.2	76.1
Hydrogen, %	13.8	11.8
Sulfur, %	0.034	< 0.005

Table 2: Contd.,		
Oxygen, %	-	12.1
Cetane Number	47	56
Flash point	62	178
Lower calorific value MJ/kg	42.59	37.243

The oil content in some of algal species mention in Table 3. [Q. Hu et. al., 2008] Although the lower energy biodiesel based on seed oils are the most common, they have enough energy density to make them a viable alternative to petroleum diesel. The interest the production of Biofuel from alge has been expressed through a booming market.

Table 3: Oil Content in Selected Algal Species

Algal Species	Oil Content (% dry weight)	Algal Species	Oil Content (% dry weight)
<i>Ankistrodesmus</i> sp.	28-40	<i>Nannochloris</i> sp.	31 (6-63)
<i>Botryococcus braunii</i>	29-75	<i>Nitzschia</i> sp.	28-50
<i>Chlorella</i> sp.	29	<i>Phaeodactylum tricornutum</i>	31
<i>Chlorellaproteothecoides</i> (autotrophic/heterothrophic)	15-55	<i>Scenedesmus</i> sp.	45
<i>Cyclotella</i> sp.	42	<i>Stichococcus</i> sp.	33 (9-59)
<i>Dunaliella tertiolecta</i>	36-42	<i>Tetraselmis suecica</i>	15-32
<i>Hantzschia</i> sp.	66	<i>Cryptocodinium cohnii</i>	20
<i>Isochrysis</i> sp.	7-33	<i>Neochloris oleoabundans</i>	35-54

R & D WORK ON ALGAE IN INDIA

In India, some of the initiatives were taken by the government for promoting algal biofuel research. In 2008-09, government of India launched a “National Algae Biofuel Network” with the participation of 12 national institutes to work on algal biofuel with focusing on aspects, such as collection and characterization of algal strains from different ecological niches and deposition of the same in three repositories, development of different production systems, improved algal strains for more oil/lipid content and finally, design development and fabrication of low-cost and pilot-scale bioreactors for the cultivation of algae for biofuels and technology.

Presently, algal biofuel research in India is mostly confined to only some of the Indian institutes (government funded research laboratories and a few other Private Indian universities). Table 4 shows the status of R & D work on algae in India's [S. Rajvanshi et. al., 2012]. It's the need that scientists of India should join the global race for research and development on algaebased biofuel whereby allowing the country to find a solution to its impending energy crisis. On a precedence basis, the possible challenges in this favor should be addressed by initiating required R & D efforts. The cost of producing algal biodiesel can be reduced significantly by using a bio-refinery based production strategy [S. Rajvanshi et. al., 2012 & J. Mata-Alvarez et. al., 2000], improving capabilities of microalgae through genetic engineering [T. G. Dunahay et. al., 1996 & R. Leon-Banares et. al., 2004] and advances in the engineering of photo-bioreactors [E. Molina Grima et. al., 1999, A. Sanchez Miron et. al., 1999 and M. Janssen, et. al., 2003].

Table 4: Status of R & D Work on Algae in India

S. No	Institution/Organization	Algae species worked	R & D area
1	University of Madras, Chennai	<i>Sargassum</i>	Cultivation
2	University of Madras, Chennai	Seaweeds	Biogas production
3	University of Madras, Chennai	<i>Botryococcus braunii</i>	Cultivation in open raceway
4	Central Food Technological Research Institute (CFTRI), Mysore]	<i>Botryococcus braunii</i>	Isolation and Characterization of hydrocarbon
5	Vivekananda Institute of Algal Technology (VIAT), Chennai	Microalgae	Development of technology to treat industrial waste water
6	Central Rice Research Institute (CRRI), Cuttack,	<i>Chlorella vulgaris</i>	Production
7	Vivekananda Institute of Algal Technology (VIAT), Chennai	Algae as Biofuel	production from diatom species
8	Indian Institute of Technology, Roorkee	Microalgae	Conversion of Microalgal oil to biodiesel

CONCLUSIONS

Algae is a promising source for biofuel production, as they can perform photosynthesis, grow in heterotrophic conditions, grow faster, do not require a special growth medium, and contain 50 % or more of their mass as oil. Carbon dioxide necessary for photosynthesis can be obtained from stationary sources of environmental air pollution, such as fuel combustion units, which would help to reduce emissions of greenhouse gases. Algal oil is similar to vegetable oil, the existing traditional biodiesel production technologies can be easily adjusted to use this new raw material.

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