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Improving the quality of fast pyrolysis algae bio-oil by distillation

J. Kuberan[1]*, N. Alagumurthi[2]
[1]Department of Mechanical Engineering, S.K.P. Engineering College, Tiruvannamalai
[2]Department of Mechanical Engineering, Pondicherry Engineering College, Pondicherry
***Corresponding author: E-Mail: kkuberdr@gmail.com**

ABSTRACT

The demand for fossil fuels increases because of the over usage and extraction of petroleum for transportation purpose and comfort life style in modern age. Energy crisis across the world because of significant growth in population and the basic industry sectors have caused environmental problems.

The hike in oil prices and change in climate condition, and harmful emission from combustion of fossil fuel, the industry sector started inverts on alternative resource.

The algae biomass converted into bio-oil through pyrolysis process and the bio-oil properties is compared with diesel fuel.

Distillation is the method of separating the substance from a liquid mixture by selective evaporation and condensation. The distillation process results in the removal of unwanted moisture content.

The bio-oil has lower content of water after distillation, than pyrolysis bio-oil. The flash and fire point of bio-oil is low, and the heating value is high so that combustion takes place at a lower temperature which in produce better combustion of the oil, Hence the distilled bio- oil has greater efficiency than pyrolysed oil.

KEY WORDS: SP-Spirullina, Pyrolysis, BF-Biofuel, Distillation.

1. INTRODUCTION

Biofuels are liquid fuels that are developed from plant or animal waste matter. The base components for bio fuels are referred as biomass and the popular is being corn. Other form of biomass includes sugarcane, soy beans, canola, and other traditional raw crops. The two most well-known biofuels are ethanol and biodiesel. Biofuels are extracted from both algae and plant seeds.

Biomass: The term “biomass” refers to organic matter that has stored energy through photosynthesis. It exists in one form in plants and transferred through the food chain to animal’s bodies and their wastes, which can be converted for everyday human use through combustion, which releases carbon monoxide stored in plant material.

Biomass is the most plentiful and well-utilized renewable energy source in the world. It is an organic material produced by the photosynthesis of light. The organic compounds of carbons are stored and can then be used to generate energy

Biofuel: Biofuels are the fuels which are produced directly or indirectly from organic materials such as wood, crops and waste materials .It can be derived from agricultural crops, including conventional food plants or special energy crops. It may also be derived from forestry, agricultural, fishery products and wastes.

Algae oil as Biofuel: The oil which is extracted from the algae through various methods can be used as biofuel. The fossil fuel releases CO_2 when burnt, but algae fuel removed CO_2 from atmosphere via photosynthesis as the algae or plant grow. Among algae fuels’ attractive characteristics the one notable is that can be grown with minimal impact on fresh water resources.

Microalgae: Microalgae are currently the most promising source of biofuels for total substitution of fossil fuels. The benefits of microalgae compared to other biomass include, their higher photosynthetic efficiencies, and higher productivity which can potentially produce substantially greater biomass yields per day and per unit cropping area. The numbers of studies that have evaluated the potential of using raw algal oil in an engine are insufficient to gain a full understanding of the likely performance of this fuel. The use of raw algal oil can overcome problems related with the use of expensive chemicals and procedures during the trans esterification reaction necessary to produce biodiesel.

Spirulina: Spirulina is single cellular blue - green algae that belong to the plant family called oscillatoriaceae. The “spirulina” family consists of various species of unicellular algae, the most common being spirulina plantensis and spirulina maxima.

Thermal Extraction: The extraction of oil is the process of using the thermal energy to extract oil from the cell in the form of vapour. Then vapour is condensed into a liquid. The oil extracted using thermal extraction process does not required any purification process.

Pyrolysis Process: Pyrolysis is a thermal-degradation process in which organic material is converted into a bio-oil, char and gas by heating in the absence of oxygen.

Classification of pyrolysis: Pyrolysis can be classified based on the heating rate as; Slow pyrolysis, Medium pyrolysis, Fast pyrolysis.

Figure.1. Pyrolysis Setup

The pyrolysis setup consists the following parts; a) Heater, b) Reactor, c) Condenser, d) Oil collector, e) Nitrogen cylinder.

Heater: The heater is a U shaped heating element and is made of nicrome wire. Only one heater has 3Kw heating capacity and 240V supply. The heater is fitted outside of reactor in the shape of U.

Reactor: The reactor is made of stainless steel, in the shape of a rectangle and the thickness is 10mm. The top side is closed with the help of nuts. The one inlet and outlet are marked. Inlet used supply the nitrogen gas and outlet transfer the volatile gases. The heater setup consists of 1 heating coils in the shape of U. This heating coil having the capacity of 3KW. These coils are supply the heat to reactor.

The heater gets the heat from heating coils, increase the temperature of heating chamber. This higher temperature is used in this pyrolysis process.

Condenser: The condenser is made up of steel and is connected to the gas liquid separator. The outlet of the reactor is directly connected to the condenser using a stainless steel tube which can withstand high temperature. Another one inlet is connected to the reactor from the nitrogen cylinder. The condenser is firmly connected with help of alloy gasket. Counter flow condenser is selected. The flow of water is directed against the direction of pyrolysis gases. The condensate drips into the gas liquid collector.

Gas and Liquid separator: The gas liquid separator is made up of steel .The condensate drips into the gas liquid separator. The gases rise to the neck of other tube and pass through the exhaust tube.

2. EXPERMENTAL WORK

Pyrolysis involves the decomposition of biomass (or other organic material) into bio-oil, syngas and charcoal in the absence of air. The pyrolysis experiments of spirulina without a catalyst over the range of temperatures were investigated and it was concluded that pyrolysis at 350°C for 2 hours is sufficient for degradation of organic compound of algae. At these conditions a dry bio-oil yield of 43% was achieved.

Extraction of oil from Spirulina: Biomass weight: 1kg, Container weight: 3.964kg, Set temperature: 350°C, Nitrogen gas supply of 0.5 kg/cm² for 2 minutes.

Figure.1. Wet Spirulina

Figure.2.Dried Spirulana

Table.1. Pyrolysis Reaction Temperature

	Time	Temperature
Starting time	11:03am	58°C
	11:45am	100°C
	12:04am	150°C
	12:12am	168°C
	12:30am	214°C
	12:49am	250°C
	1:08pm	300°C
End	1:23pm	350°C

Table.2. Products from Pyrolysis Process

Weight of the container with biomass	Content
At beginning process	4.964 kg
At end of the process	4.262 kg
Weight of oil & gas	0.702 kg
Weight of the oil	0.439 kg
Charcoal weight	0.298 kg

Distillation: The bio oil contains higher water content after extraction. The reduction of the water content will mainly influence on heating value. The bio oil is heated at 100ºC about an hour during this process the water content present in the oil is vaporized and viscosity of the oil is increased.

Figure.3. Distillation setup

Table.3. Analysis of Distillation process

SP Oil ml	Temperature	DSP Oil	water consent ml	% of water content
200	100	135	40	20

Table.4. Comparison of properties

Spirulina Extraction Temperature	Density (ρ) kg/m³	Flash point °C	Fire point °C	Kinematic Viscosity Centistoke	Calorific value KJ/kg
At 350°c	1019	125	150	0.81931	31200
After Distillation process	907	87	91	2.72	32400

3. RESULT AND ANALYSIS

Extraction of oil from Spirulina at 350°C: One Kg of sample spirulina is taken for testing and total time to complete the process is 2 hrs. The maximum temperature reached is 350°C. Weight of oil is 0.439kg.

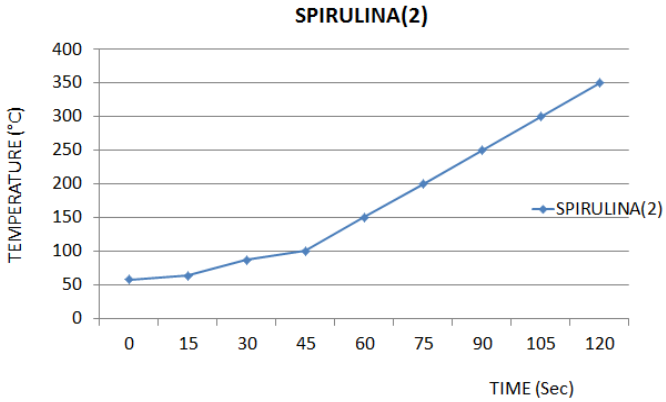

Figure.4.Rate of extraction of Spirulana with the increase in temperature

Table.5. Comparison of Bio-oil property

Fuel	Density (ρ) kg/m³	Flash point °C	Fire point °C	Kinematic Viscosity Centistoke	Calorific value KJ/kg
Diesel	943	50	57	2.98	45000
SP	1050	119	146	0.83931	31200
DSP	907	87	91	2.72	32400

FTIR Analysis: Fourier transform infrared spectroscopy (FTIR) is a method which is used to obtain an infrared spectrum of absorption, emission and photoconductivity of a solid, liquid or gas. It measures intensity over a narrow range of wavelength at a time.

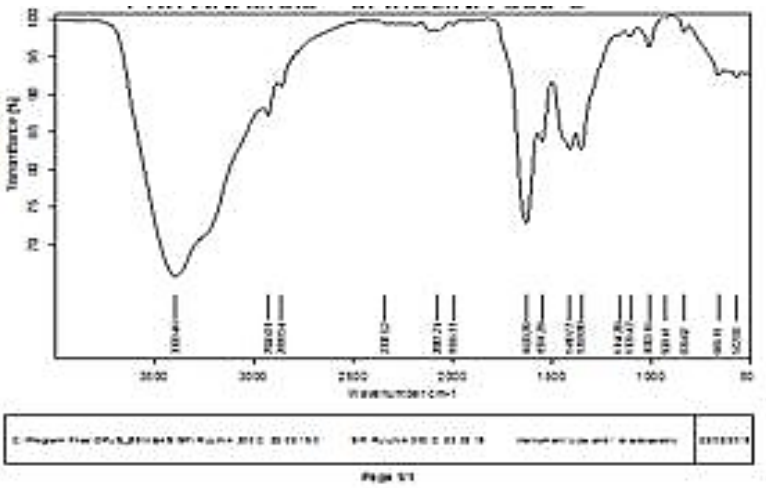

Figure.5.FTIR of Spirulana

4. CONCLUSION

Algae oil extracted from pyrolysis method which produce biodiesel at low cost, elimination of purification process, lower viscosity fluid over oil extracted by other methods.

The oil is extraction from spirulina at temperature 350°C the maximum oil is extracted from spirulina weight about to 43.9% and heating value is 31MJ/Kg.

Due to distillation process all the property of the distilled spirulina oil very near to diesel fuel and heating value increase up to 32.4 MJ/Kg.

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