IMPROVING PHYSIO-CHEMICAL PROPERTIES OF BIODIESEL

Submitted in the partial fulfilment of the requirements degree of

MASTER OF TECHNOLOGY

IN

AUTOMOBILE ENGINEERING

BY

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GREATER NOIDA

2020

CERTIFICATE

This is to certify that the Research work titled that is being submitted by **GAURAV PATHAK** is in partial fulfillment of the requirements for the award of **Master of Technology in Automobile Engineering**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor

Internal Examiner **External Examiner**

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This dissertation report entitled by and is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

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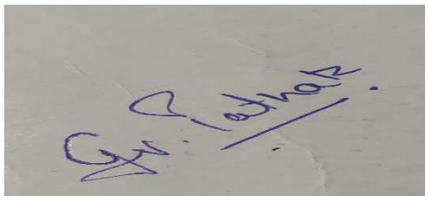

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ABSTRACT

As the population is rising day by day in this world we humans are getting on the shortage of our fuel supplies, as with this constant increase in the demand and the need of an alternative solution for the gasoline that has carried the humanity for several long periods of time is now getting depleted. So keeping in mind with our of environmental concerns we tend to do experiments on finding an alternative fuel to be used for energy serving a purpose and that fuel must be environment-friendly. In this research, we hereby use the seeds of jatropha and mahua to create a biodiesel fuel. For performing this experiment we will be performing a two-step trans-esterification process to form a biodiesel, in which blends of jatropha biodiesel and mahua biodiesel are used. Improvements to the physiochemical properties for jatropha oil were also observed while performing the experiments.The change helps in improving the properties of fuel. The experiments concluded to us that the blending of madhuca and jatropha biodiesel significantly improved the physio-chemical and cold flow properties of biodiesel.

INTRODUCTION

As our industrial technology is increasing day by day we are getting close to the depletion of our reserved fossil fuels. As with the increase in our demands for energy sources, the exploration of alternative forms of energy sources is trending for clean and environment-friendly fuels such as biodiesel and blends of petroleum and diesel are into play these days. These fuels are non pollutant and non-toxic in nature. Some of the alternative fossil fuels such as corn and palm oil, oil of soya bean and sunflower. As our diesel engines can work with pure biodiesel and blends of petroleum diesel we get an energy source that is more environmentally friendly. Biodiesel are easily formed with cheaper raw materials such as non edible vegetable oil, jatropha oil, mahua oil, etc are used for the production of biodiesel , jatropha oil is one of the best options available to us for making of biodiesel as the properties of this oil is nearly identical to those of mineral diesel and can be used as an alternative fuel with some modifications. Flashpoint, ignition point and viscosity of jatropha oil are also higher.

Advantages of biodiesel

1. Biodiesel can be served as alternative fuels and are more environment friendly.
2. Biodiesels produces less carbon emissions when compared to diesel fuels.
3. They are cheaper to produce and are also biodegradable and non-toxic when burnt.
4. Two step Trans-esterification process is used to make biodiesel using alcohol such as ethanol or methanol and vegetable oils or animal fats.
5. Plants are the most appropriate source of raw material. Vegetable oil such as jatropha oil, mahua oil, soya-bean oil, palm oil are other sources of obtaining biodiesel.
6. Biodiesel has a high flash point which makes them less volatile and is easily transported.
7. Lubrication properties of biodiesel are also good which means it can extend the engine life span and reduces the chance of wear and tear of internal parts of the engine.

Jatropha

It belongs to the euphorbiaceous family which also had 175 other species in it, this species of plant is more than almost 60 million years old. These plants are said to be originated from central America and the southern parts of South America. Now, these jatrophas can also be found in south-east Asia, Indian subcontinents, Africa and some countries with sub-Sahara. Jatropha plant is said to be like a shrub which is approximately 6 meters in height but in some countries such as South America these are said to have 12 meters of height, these plants have a lifespan of approximately 45-50 years and are also categorized as the monoecious plant i.e these plants have male and female reproductive organs. The seeds of these plants are of length ranging between 2.5 cm to 3 cm, these seeds are used for taking out the jatropha oil. As the jatropha great adaptability to suit itself according to different climatic conditions it can be grown anywhere like with soil with low fertility, high fertility areas, stony regions, shallow and dry regions, these plants can absorb the nutrition from the soil very effectively no matter the state of the soil.

Jatropha curcas with seeds

Madhuca Curcas

Madhuca is also known as Mahua and it is a tropical plant which is found in central and northern plains and forests of India. It has a maximum height measuring up to 20m and it grows rapidly. Major species found in India are Madhuca indica and madhuca longifolia.Non edible oil that has approximate production of 60 million tonnes. It has high adaptability to arid enviroments, with annual rainfall ranging from 550=1500mm.It takes upto 10 years for the seed production and has a life span of upto 60 years.The seed contains 35%-50%oil and the kernel contains 50% .The total oil yield for the mahua oil is 2700 kg. The oil contains about 20% FFAs and a producer for converting this oil to biodiesel is required.

LITERATURE REVIEW

To improve the properties of biodiesel we use the blends of two different oil along with purified diesel. Blending of biodiesel is done by mixing the biodiesels in different ratios and the property of each blend is experimentally determined.

- ***Comparative Study of Stability Characteristics of Mahua and Jatropha Biodiesel and its Blends:- N. Acharya (2017)***

  According to the author, he concluded that in comparison to jatropha biodiesel and mahua biodiesel, the jatropha is more prone to oxidation. Therefore with the blending procedure oxidation stability will be increased.

- ***Overview of fuel properties and prospects of Jatropha biodiesel as a fuel for engines:- Sunil Thapa(2017)***

  Jatropha biodiesel has desirable advantages over normal diesel. Properties such as Flash point, Fire point, Cloud point etc. Emissions such as HC, C, CO_2.

- ***International experiences with the cultivation of Jatropha curcas for biodiesel production:- Nirza fabiola castro gonzals(2016)***

  Plants can be a solution to our various energy problems as they can solve our problems that are based on our emissions, costs, etc.

- ***Biodiesel production from vegetable oils via catalytic and non-catalytic supercritical methanol transesterification methods:- Ayhan Demirbas***

  Vegetable oils have the advantage of not being exhaustible and these are renewable and its properties are similar to diesel fuel. Earlier the biodiesel was not used because of the price as they were more costly the other fuels like petrol. But now the vegetable oil is getting its attention because of the increasing price of petrol and availability.

- ***Review of Jatropha curcas: an oil plant of unfulfilled Promise:- Keith Openshaw***
  Jatropha plant has much use and advantages like it can reclaim land by being a crop that is commercially being used for biodiesel production and it is also a tropical plant that can grow anywhere like high or low rainfall areas. Besides that, it can also improve the lives of people living in rural areas by giving them work to do.

- ***Biodiesel production:- Fangrui Ma, Milford A., and Hanna, Milford A. Hanna***
  In the commercialization of biodiesel in the market cost is the main problem or the reason because of which it has been difficult. The chemical properties along

with, reaction time and water content of oils or fats these are the reason the transesterification reaction is disturbed.

Experimentation on performing the transesterificatrion

- **Procedure**
  1. Pour the oil in the beaker
  2. Place the sample into a water bath and heat it at 100 degrees Celsius for 30 minutes
  3. Stir the sample while heating again and again with 5 minutes gap
  4. Keep the oil temperature at 70 degree Celsius
  5. Filter out the sample using filter paper
  6. The sample is done added with the mixture of methanol and sulphuric acid
  7. Again heat the sample in a water bath at a constant temperature for approximately 2 hours
  8. Stir the sample every 15 minutes while heating
  9. Pour the sample in the separating funnel and allow it to settle down
  10. We will obtain the methoxide solution consisting of methanol and potassium hydroxide is obtained
  11. Remove the sample from separating funnel
  12. Put the layers of oil and water into different beaker
  13. Pour the methoxide solution in the oil
  14. Again heat the sample using a water bath for 1 hour
  15. Stir the sample every 10 minutes
  16. Place it in the separating funnel
  17. Leave the sample overnight to properly settle down at the bottom
  18. Collect the sample of glycerol and biodiesel into a separate beaker
  19. Calculate the percentage of yield produced in the sample

Yield= (jatropha biodiesel obtained/jatropha oil used)*100

Fig: Jatropha biodiesel

Fig: Waterbath

Empty glass funnel

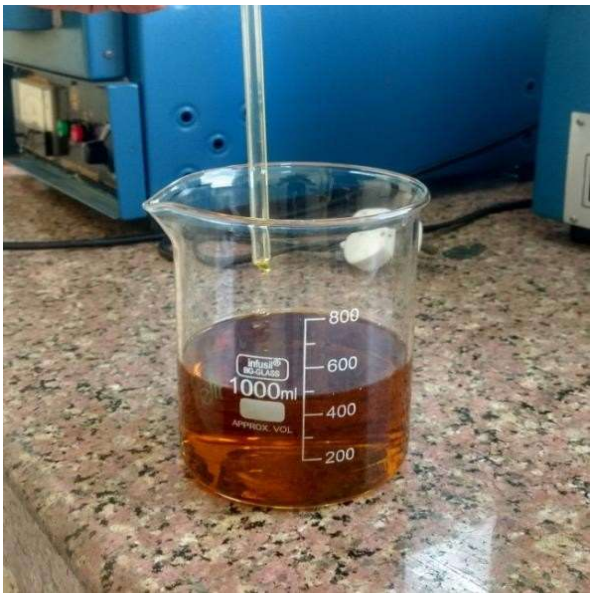
Mixture of methanol and sulphuric acid

Pre-treated jatropha oil

Methoxide solution consisting

Methanol and potassium hydroxide

Jatropha Biodiesel along with Glycerol.



Jatropha Biodiesel obtained after trans-esterification.

EQUIPMENT:-

- Beaker
- Water bath
- Measuring cylinder
- Sparting funnel
- Thermometer
- Filter paper
- Pipette

PARAMETERS:-

- The sample was initially heated to 100°C.
- The sample temperature was maintained between (70^o C-90^o C).
- A sample is prepared under normal atmospheric temperature.
- 500ml of jatropha oil was taken.
- 350ml of mahua oil was taken.
- 5ml of sulphuric acid was taken.
- For obtaining a methoxide solution we use 150ml of methanol was taken.
- 5gm of potassium hydroxide was taken.

READINGS:-

- Approximately 440 ml of yield was obtained
- 88% yield was achieved

Kinematic Viscosity

Procedure:-

- The B10 (10% Jatropha biodiesel, 10% Mahua biodiesel, 80%Mineral diesel) blend is poured into the oil cup up to the tip of an indicator.
- Oil is heated up to 40 degree Celsius.

- Then the brass ball is lifted to let the oil flow into the beaker placed below.
- The time taken to empty 50 ml of sample from oil cup is noted and according to that the viscosity will be calculated with the formula given below.

Kinematic Viscosity = (At)-(B/t)

Where, A= 0.26; B= 171

t= time taken to fill the beaker.

Fig: Redwood Viscometer

Equipment:

- **Redwood Viscometer.**
- **Beaker.**
- **Measuring cylinder.**
- **Thermometer.**

Parameters:

- The sample was poured in the cup.

- The sample was heated up to 40°C.
- The sample was tested under atmospheric pressure.
- Kinematic Viscosity was measured in centistokes (CST) at
- 40^{o} C temperature with the help
- of Redwood Viscometer.
- The following samples were used :
  a. **B10 = A mixture of 5% Madhuca Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel.**
  b. **B20 = A mixture of 10% Madhuca Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel.**
  c. **B30 = A mixture of 15% Madhcua Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel.**

Readings:

SAMPLE	KINEMATIC VISCOSITY
B10	3.12
B20	4.15
B30	5.0
Jatropha Biodiesel	5.78
Mahua Biodiesel	5.69

Specific Gravity:

Process: Specific gravity bottle weight is measured**.**

- 10ml of sample is poured into a specific gravity bottle**.**
- The weight of the sample is noted**.**
- Specific gravity formula**:**

Specific Gravity = (weight of sample – the weight of bottle)/volume of a sample.

Measuring the specific gravity of the sample using a digital scale

Equipment:

- The digital balance scale was used to measure the weight of the bottle and the weight of the sample.

Parameters:

- 10ml of sample was poured into the bottle
- The samples were weighed under normal atmospheric pressure.
- The samples were weighed at room temperature.
- The following samples were used:
  a. **B10 = A mixture of 10% Mahua Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel.**
  b. **B20 = A mixture of 20% Mahua Biodiesel, 20% Jatropha Biodiesel and 60% mineral diesel**
  c. **B30 = A mixture of 30% Mahua Biodiesel, 30% Jatropha Biodiesel and 40% mineral diesel.**

Readings:

SAMPLE	SPECIFIC GRAVITY
B10	0.8518
B20	0.8628
B30	0.8754
JATROPHA BIODIESEL	0.8670
MAHUA BIODIESEL	0.8897

Density:

Process:

- Density is calculated using the formula:

Density = Specific Gravity * Density of water

Parameters:

- Taking the density of water as 997 kg/m ^3.
- The following samples were used:

a. **B10 = A mixture of 10% Mahua Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel.**

b. **B20 = A mixture of 20% Mahua Biodiesel, 20% Jatropha Biodiesel and 60% mineral diesel.**
c. **B30 = A mixture of 30% Mahua Biodiesel, 30% Jatropha Biodiesel and 40% mineral diesel**

Readings:

SAMPLE	DENSITY
B10	0.849
B20	0.860
B30	0.872
Jatropha Biodiesel	0.887
Mahua Biodiesel	0.864

Acid Value:

Process:

- Take 10 ml of raw jatropha/mahua oil in a flask.
- Add 50 ml of ethanol (absolute) to it.
- Heat it at 70 degree Celsius.
- Using the formula of acid value (AV) = Acid Value = (56*volume of KOH consumed*normality of KOH)/ mass of sample
- [Normality = molecular mass of KOH/10 = 56/10 =5.6 g of KOH]

[Molecular mass of KOH = 1x39+1x16+1x1 = 56]

- Jatropha biodiesel:-Pink color occurred at 1.5, Therefore, AV = 5.6x1.5x0.1/10 = 0.84
- FFA (free fatty acids) = 0.42252
- Mahua biodiesel: - Pink color occurred at 0.8
- Therefore, AV = 56 x 0.8 x0.1/10 = 0.448 FFA (free fatty acids) = 0.225344
- B10 duel fuel: - Pink color occurred at Therefore, AV = 5.6 x _ x 0.1/10 = 0.84 FFA (free fatty acids) = 0.42252
- b20 duel fuel:- Pink colour occurred at Therefore, AV = 5.6 x _ x 0.1/10 = 0.84 FFA (free fatty acids) = 0.42252

- B30 duel fuel:- Pink colour occurred at Therefore, AV = 5.6 x _ x 0.1/10 = 0.84 FFA (free fatty acids) = 0.42252

Equipment:

- Conical flask
- Thermometer
- Titration flask

Parameters:

- 10ml of the sample was taken to be tested.
- 50ml of absolute ethanol was taken.
- The mixture was heated to 70°C.
- 3 drops of phenolphthalein were added to the mixture.
- The sample was tested under normal atmospheric pressure.
- KOH of 0.1 normality was taken for titration.
- The following samples were used :

a. **B10 = A mixture of 5% Mahua Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel.**
b. **B20 = A mixture of 10% Mahua Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel.**
c. **B30 = A mixture of 15% Mahua Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel.**

Readings:

SAMPLE	ACID VALUE
B10	0.506
B20	0.67
B30	0.702
Jatropha Biodiesel	0.84
Mahua Biodiesel	0.448

SAMPLE	Free Fatty Acid
B10	0.254
B20	0.337
B30	0.353
Jatropha Biodiesel	0.423
Mahua Biodiesel	0.225

Flash Point:

Process:

- The oil cup was cleaned using solvent.
- The cup was filled with fresh samples up to the mark.
- The cup was placed in the apparatus bath.
- The lid is placed on the cup and the thermometer was also inserted.
- The electrical heater was turned to 50% of the input voltage and oil is heated.
- After that spring handle was rotated at every degree rise from this point.
- The temperature was noted at which the flash occurs.
- The experiment was repeated for different samples.

Pensky-Marten Apparatus to determine the Flash and Fire Point of a sample.

Equipment:

- Pensky-Marten apparatus.
- Voltmeter.
- Beaker.
- Thermometer.
- Lighter.

Fig: Pensky-Marten Apparatus to determine the Flash and Fire Point of a sample.

Parameters:

- The sample was tested under normal atmospheric conditions.
- The input voltage was set to 50% fo input voltage.
- The following samples were used :
  a. **B10 = A mixture of 5% Mahua Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel**
  b. **B20 = A mixture of 10% Mahua Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel**
  c. **B30 = A mixture of 15% Mahua Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel**

Readings:

SAMPLE	FLASH POINT
B10	73
B20	83
B30	100
Jatropha Biodiesel	205
Mahua Biodiesel	238

Fire Point:

Process:

- The oil cup was cleaned using solvent.
- The cup was filled with fresh samples up to the mark.
- The cup was placed in the apparatus bath.
- The lid is placed on the cup and the thermometer was also inserted.
- The electrical heater was turned to 50% of the input voltage and oil is heated.
- After that spring handle was rotated at every degree rise from this point.
- The temperature was noted at which the flash occurs.
- The fire point was noted at which the fuel burnt continuously for 5 seconds.
- The experiment was repeated for different samples.
- Pensky-Marten apparatus.
- Voltmeter.
- Beaker.
- Thermometer.
- Lighter

Parameters:

- The sample was tested under normal atmospheric conditions.
- The input voltage was set at 50% of the input voltage.
- The following samples were used :

a. **B10 = A mixture of 5% Mahua Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel.**
b. **B20 = A mixture of 10% Mahua Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel**
c. **B30 = A mixture of 15% Mahua Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel**

Readings:

SAMPLE	Fire Point
B10	85
B20	95
B30	112
Jatropha Biodiesel	245
Mahua Biodiesel	218

Cloud point:

Process:

- The sample is poured into a test tube.
- The apparatus bath was filled with crushed ice.
- The sample is then placed inside the apparatus.
- The temperature at which cloudy appearance was noted at the test tube wall marked as the cloud point of the sample.

Equipment:

- Cloud and Pour Point Tester
- Beaker
- Test tube
- Thermometer

Parameters:

- 50ml of the sample was poured into the test tube.
- The sample was tested under normal atmospheric pressure.
- The following samples were used :
  a. **B10 = A mixture of 5% Madhuca Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel**
  b. **B20 = A mixture of 10% Madhuca Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel**
  c. **B30 = A mixture of 15% Madhuca Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel**

Readings:

SAMPLE	CLOUD POINT
B10	0
B20	3
B30	5
Jatropha Biodiesel	9
Mahua Biodiesel	-1

Pour Point:

Process:

- The sample is poured into a test tube.
- The apparatus bath was filled with crushed ice.
- The sample is then placed inside the apparatus.
- The temperature at which the sample starts losing its flow characteristics marked the pour point of the sample.
- Cloud and Pour Point Tester
- Beaker
- Test tube
- Thermometer

Parameters:

- 50ml of the sample was poured into the test tube.
- The sample was tested under normal atmospheric pressure.
- The following samples were used :
  a. **B10 = A mixture of 5% Madhuca Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel**
  b. **B20 = A mixture of 10% Madhuca Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel**
  c. **B30 = A mixture of 15% Madhuca Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel**

Readings:

SAMPLE	POUR POINT
B10	-3
B20	-2
B30	0
Jatropha Biodiesel	2
Mahua Biodiesel	-3

Blends:

- B10 = A mixture of 5% Madhuca Biodiesel, 5% Jatropha Biodiesel and 90% mineral diesel.

Blend B10

- B20 = A mixture of 10% Madhuca Biodiesel, 10% Jatropha Biodiesel and 80% mineral diesel.

Blend B2

- B30 = A mixture of 15% Madhuca Biodiesel, 15% Jatropha Biodiesel and 70% mineral diesel.

Blend B30

- **Glycerol**

Fig : Glycerol

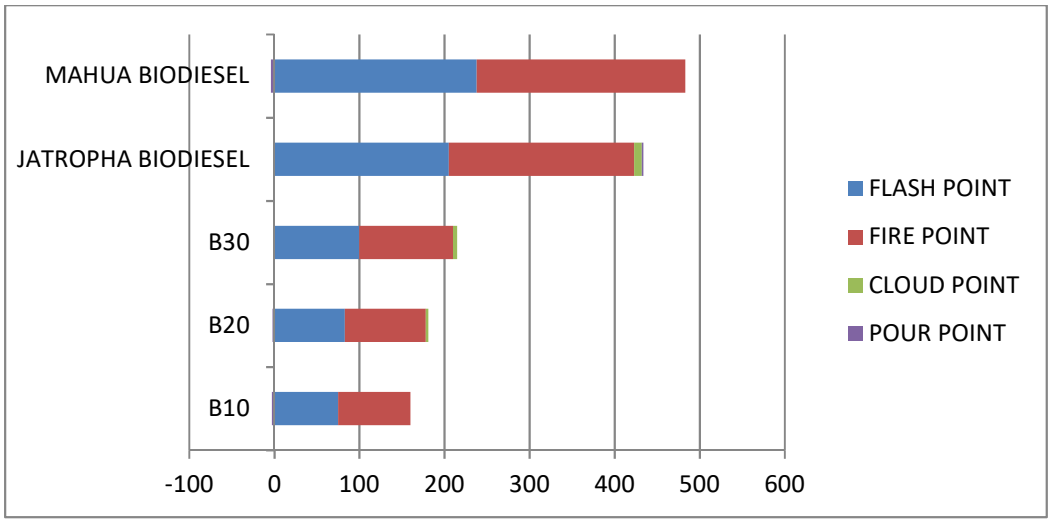
- **Jatropha biodiesel**

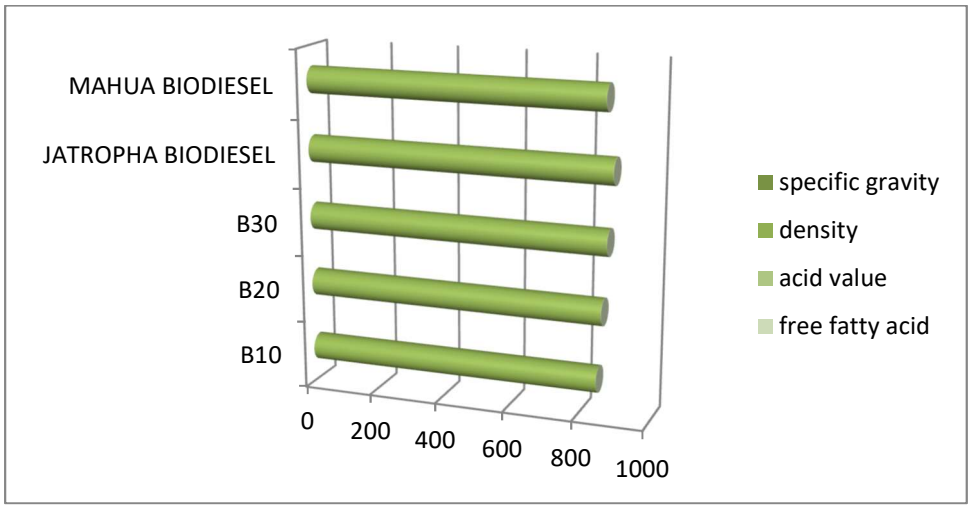
Fig : Jatropha biodiesel

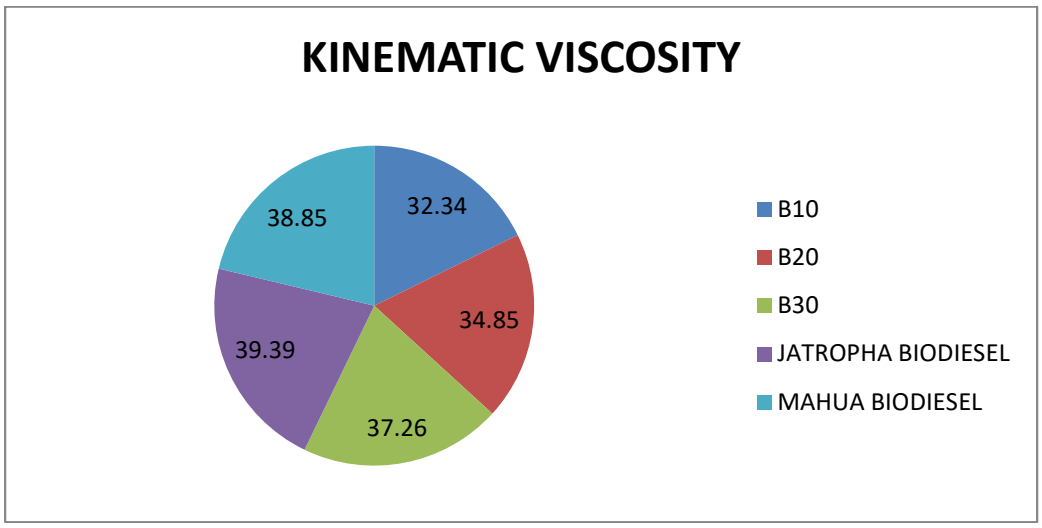
Table of observations obtained

	B10	B20	B30	Jatropha biodiesel	mahua biodiesel
Kinematic viscosity In CST	3.12	4.15	5.0	5.78	5.69
Specific gravity	0.8518	0.8628	0.8754	0.867	0.8897
Density	849.2556	860.2116	872.7738	887.0309	864.399
Acid value	0.506	0.67	0.702	0.84	0.448
Free fatty acid	0.254	0.337	0.353	0.423	0.225
Flash point	73	83	100	205	238
Fire point	85	95	112	218	245
Cloud point	0	3	5	9	-1
Pour point	-3	-2	0	2	-3

GRAPHS:


MAHUA BIODIESEL
JATROPHA BIODIESEL
B30
B20
B10
-100
0
100
200
300
400
500
600
FLASH POINT
FIRE POINT
CLOUD POINT
POUR POINT


MAHUA BIODIESEL
JATROPHA BIODIESEL
B30
B20
B10
0
200
400
600
800
1000
specific gravity
density
acid value
free fatty acid


KINEMATIC VISCOSITY
32.34
34.85
37.26
39.39
38.85
B10
B20
B30
JATROPHA BIODIESEL
MAHUA BIODIESEL

CONCLUSION :

Biodiesel is an alternative fuel that can help in making the ecological balance by giving rise to the agricultural industry. And it is also an efficient and environmentally friendly alternative fuel. In our study and experimentation, A yield of 88% which is 440 ml approx. of biodiesel was extracted from raw jatropha oil and two-step transesterification is used with potassium hydroxide as a base catalyst. The free fatty acid content of jatropha oil was found to be 4.084% which reduced to 0.422 % by the addition of 5% of concentrated sulphuric acid which resulted in the acid esterification of the oil. The acid value of jatropha oil was determined to be 8.12 which, after transesterification, came down to 0.84. The kinematic viscosity of jatropha oil which lies between 50-55 was reduced to 5.78 centistokes. The blended fuels have depicted some marvelous properties as compared to the individual biodiesel. Thus, it is true to say that the blends of biodiesels are an effective way of improving the Physico-chemical properties of the biodiesel.

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