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Production of Mahua Methyl Ester as a fuel replacement to diesel (a laboratory study)

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Abstract*— Energy is a crucial input in the process of economic, social and industrial development. Besides, the other three classical factors, i.e. land capital and labour, energy is of vital importance in the economic and social context. It is also evident that energy sources such coal, oil and gas which is essentially fossil energy source can be bought in the domestic and international market. Though all energy sources are produced in nature, the production of fossil energy sources such as coal, oil and gas takes millions of years. These sources are being consumed by the world at much faster rate than their replenishment, with their limited availability, these sources are likely to be exhausted in another century and hence there is a urgent need to find out some alternatives for these energy resources. In the present investigation an effort has been made to produce mahua biodiesel from madhuca indica oil which can be used as a substitute for diesel. The use of biodiesel is rapidly expanding around the world, making it imperative to fully understand the impacts of biodiesel on the diesel engine combustion process and pollutant formation. Biodiesel is known as the mono-alkyl-esters of long chain fatty acids derived from renewable feed stocks, such as, vegetable oil or animal fats, for the use in compression ignition engines

***Index Terms*—Mahua Oil (Madhuca Indica Oil).**

I. INTRODUCTION

The desire to higher efficiencies , lower specific fuel consumptions and reduce emissions in modern internal combustion engines has become the focuses of researchers and manufactures for the past three decades. The global concern over the decreasing supply of the fossil fuels and the more stringent emissions regulations have compelled the engine industry to produce practical, economical and environmentally conscious solutions to power our vehicles. Over the years, a variety of different approaches have been attempted to attain improvements in efficiency and reduce emissions in existing engine design , the introduction of new technology has played a role in making advancements to this century old technology. Although, lighter and strong materials, advanced manufacturing processes, improved design of combustion and new computational means have helped us in raising the performance and efficiency but in the present investigation we have tried to produce the biodiesel from madhuca indica oil and have compared the various properties of this biodiesel with pure diesel so that it may be used as viable alter native fuel.

II. BIODIESEL PRODUCTION IN LABORATORY

Biodiesel is the produced by combining vegetable oil or animal fat with an alcohol in the presence of a catalyst through a chemical process known as " transesterefication" oil for biodiesel production can be extracted from almost any oil seed crop, globally, the most popular sources are rapeseed in Europe and soya bean in brazil and USA. In tropical and subtropical countries, biodiesel is produced from palm, coconut, jatropha, cotton seed and mahua seeds. The production process typically yields additional by-products such as crushed bean "cake" (an animal feed) and glycerine. because biodiesel can be based on a wide range of oils, the resulting fuels can display, a greater variety of physical properties such as viscosity and combustibility. Its energy content is 88-95% of diesel but it improves the lubricity of diesel and raises the cetane value, making the fuel economy of both generally comparable. the higher oxygen content of bio-diesel aids in the complete combustion, air pollutants , carbon monoxide and hydrocarbons.

III. RAW MATERIALS USED FOR BIODIESEL PRODUCTION

Different raw materials are used to produce biodiesel globally and some of the materials are listed as given below.

- Mahua Seed,
- Pongamia Pinnata
- Jatropha curcas
- Rapeseed (Europe)
- Sunflower oil (Italy, France and Thailand)
- Soya bean oil (USA & Brazil)
- Palm oil (Malaysia)
- Line seed and olive oil (Spain)
- Cottonseed oil (Greece)
- Jatropha, palm, pongamia & Indian mustard feed stocks (India)

IV. STEPS INVOLVED IN BIO-DIESEL PRODUCTION PROCESS

Various steps are involved in the production of biodiesel and they have been discussed as below.

1. Purification

The vegetable oil is filtered to remove dirt, charred food, and other non-oil material often found. Water is removed because its presence causes the triglycerides to hydrolyze to give salts of the fatty acids instead of undergoing transesterification to give biodiesel. At home, this is often

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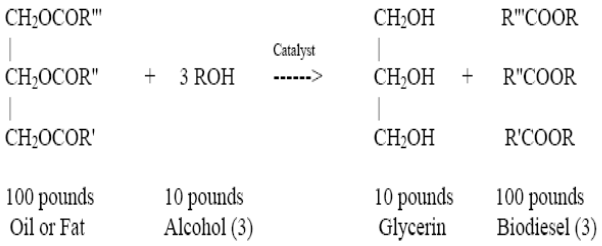
accomplished by heating the filtered oil to approximately 120 °C. At this point, dissolved or suspended water will boil off. When the water boils, it spatters (chemists refer to it as "bumping"). To prevent injury, this operation should be done in a sufficiently large container (at most two thirds full) which is closed but not sealed.

2. *Neutralization of free fatty acids*

A sample of the cleaned oil is titrated against a standard solution of base in order to determine the concentration of free fatty acids (RCOOH) present in the vegetable oil sample. The quantity (in moles) of base required to neutralize the acid is then calculated.

3. *Transesterification*

This process involves heating the mahua oil, from which the biodiesel fuel is extracted. When the temperature of approximate 65 to70 ºC. The oil is held in that temperature for certain period of time exactly 25 minutes. In this preparation, for 1000 ml of mahua oil, 300 ml of methanol and 30g of potassium hydroxide are added. The mahua oil chemically reacts with alcohol in the presence of a catalyst to produce methyl esters. After this the whole mixture is stirred for 1 hour. After completing the mixing stage, a separating flask allows the mixture to settle down. Separating and settling can be done on a single flask. When allowing the mixture to be in the flask for 24 hours the settling takes place where the glycerin gets settled down and esters get separated up. After separation of the methyl esters, it is washed in order to get clear solution of methyl esters, obtained by the spraying of distilled water over the solution which has already been separated and the moisture is removed. The reaction is shown in below.



(Mahua oil kept for reaction)

4. *Separation*

Once the reaction is complete, two major products exist: glycerine and biodiesel. Each has a substantial amount of the excess methanol that was used in the reaction. The reacted mixture is sometimes neutralized at this step if needed. The glycerine phase is much denser than biodiesel phase and the two can be gravity separated with glycerine simply drawn off the bottom of the settling vessel. In some cases, a centrifuge is used to separate the two materials faster

(Separation of glycerine from biodiesel)

5. *Final process (water wash)*

After separating from the glycerine, the biodiesel is sometimes purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage. In some processes this step is unnecessary. This is normally the end of the production process resulting in a clear amber-yellow liquid with a viscosity similar to parodies. In some systems the biodiesel is distilled in an additional step to remove small amounts of colour bodies to produce a colour less biodiesel.

(water wash and separation of biodiesel from water)

(Biodiesel stirring at 100^{0}C & pure mahua biodiesel)

Now the mahua methyl ester is heated to 100^{0}C to remove any trace of water left over in it, heating removes all the moisture and water providing to it a clear light yellow colour as show in above figure.

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V. PROPERTIES OF MAHUA METHYL ESTER & DIESEL FUEL

Properties	MME	Diesel
Density(15°C), kg/m3	880	850
Specific gravity	0.916	0.85
Kinematic viscosity at 40^0C, mm^2/s	5.8	3.05
Calorific Value (kJ/kg)	39400	42800
Flash Point °C.	129	56
Fire Point °C.	141	63

VI. ADVANTAGES OF BIODIESEL

- Environment friendly
- Clean burning
- Renewable fuel
- No engine modification
- Increase in Engine life
- Biodegradable & non toxic
- Easy to handle and store.
- Pollution threat
- Reduction of green house gas emission
- 100% domestic fuel.
- In future cheaper than diesel.
- Oil is safe, toxic and Biodegradable.
- Need no change in refuelling infrastructures and spare part Inventories.
- Cetane number is significant higher than diesel.
- Has a high flash point compare to diesel
- Less polluting: - They emit approximately 80% less CO_2 and almost 100% less Sulphur dioxide.
- Oil contains 11 % oxygen. So that it burn totally. Whereas in diesel oxygen is nil.
- Regional development
- Social structure & Agriculture

VII. ENVIRONMENTAL BENEFITS

- In 2000, biodiesel became the only alternative fuel in the country to have successfully completed the EPA-required Tier I and Tier II health effects testing under the Clean Air Act.
- These independent tests conclusively demonstrated biodiesel's significant reduction of virtually all regulated emissions, and showed biodiesel does not pose a threat to human health
- Biodiesel contains no sulfur or aromatics, and use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter.
- A U.S. Department of Energy study showed that the production and use of biodiesel, compared to petroleum diesel, resulted in a 78.5% reduction in carbon dioxide emissions.

  Moreover, biodiesel has a positive energy balance. For every unit of energy needed to produce a gallon of biodiesel, 3.24 units of energy are gained.

VIII. CONCLUSIONS

The results of the laboratory are encouraging and from the laboratory studies, the following important conclusions are drawn:

- Bio-diesel can be successfully used as a substitute fuel to the diesel and thus will help in fulfilling the increased demand of fuel.
- Biodiesel is more eco-friendly in comparison to petroleumdiesel and its performance as fuel is almost atpar with diesel.
- It is helpful in reducing the fossil fuel requirements and hence the fossil fuel reservoirs may be used for a longer time.
- It may be helpful in putting the barren land under cultivatun.
- It may helpful for the farmers by generating extra income from irrigated land during off season.
- Since use of biodiesel helps in getting the reduction of virtually all regulated emissions and as a result it does not pose any threat to human health.
- A U.S. department of energy revealed that the use of biodiesel in comparison to petroleum diesel resulted 78.5% reduction in carbon dioxide emission and so gives less polluting environment.
- Since agriculture commodities have low price in comparison to petroleum products, hence it give better energy security at lowest price.

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