Production of biodiesel from Mahua oil by tranesterification method to overcome the diesel price increment

P. Vetrivel [1] and Dr. C. Solaimuthu [2]

[1] *P.G Scholar cum Assistant Professor, Department of Mechanical Engineering, Jayam College of Engineering and Technology, Dharmapuri – 636 813, Tamil Nadu, India*

[2] *Professor cum Director (Research), Department of Mechanical Engineering, Er. Perumal Manimekalai College of Engineering, Hosur – 635 117, Tamil Nadu, India*

***ABSTRACT* -- Mainly vegetable oils are used for the production of biodiesel. Several types of fuels can be derived from triacylglycerol-containing feedstock. Biodiesel can be defined as the mono-alkyl esters of animal fats or vegetable oils such as edible/non-edible oils. Biodiesel is produced by transesterification method by adding a methyl alcohol under mild conditions in the presence of a base catalyst. The present study discusses about fuel production and its properties. This also describes the use of glycerol which is the by-product in esterification process along with biodiesel. The impact of biodiesel and diesel on the diesel engine has described.**

Index Terms - Mahua Oil, Biodiesel, transesterification, Properties

I. INTRODUCTION AND LITERATURE SURVEY

Continuing depletion of the reserves of non-renewable petroleum, price volatility, feedstock availability concerns have caused an intensified search for alternative sources of energy. Biodiesel derived from biological sources, among them lipid materials such as fats and oils have received increasing attention. Different processes for biodiesel production using fats and oils as a feedstock yields fuels with different composition and properties [1, 2]. Biodiesel which is defined as the mono-alkyl esters of vegetable oils or animal fats, obtained by transesterifying oil or fat with an alcohol. The major reason for not using a neat vegetable oil as fuel is its high viscosity (28-40 mm^2/s), which leads to operational problems in diesel engine including formation of deposits into the injector choking due to poorer atomization upon injection into the combustion chamber. Transesterification of the oil reduces the viscosity of the oil to a range (4-5 mm^2/s) closer to that of petro diesel. The combustion of petroleum based fuels causes environmental problems, which threaten wild and human life, impacts on the environment and human health. Further global warming is caused of emission of CO, SO_2 and NO_X etc as the combustion products. Its part in global warming potential has increased from year by year and now bigger than those of the domestic and industrial sector. It was stated by Lloyd and Cackete [3] that diesel emission contributes to the development of cancer, cardiovascular and respiratory health effects; pollution of air, water and soil; soiling; reductions in visibility and global climate change. There are many works on reliable researching and implementation and useful results come to exist. The alternative fuels must be technically acceptable, economically competitive, environmentally acceptable and easily available. Research on biodiesel derived from vegetable oils and animal fats are being maintained to alternate this kind of fuels to petroleum based diesel fuel. It has been concluded by many studied that as an alternative engine biodiesel reduce the emissions of carbon monoxide (CO), hydrocarbons (HC), sulphur dioxide (SO_2), Polycyclic Aromatic Hydrocarbons (PAH), nitric Polycyclic Aromatic Hydrocarbons (nPAH) and particulate matter (PM) by NO_X to increase in the exhaust as compared with diesel fuel [4, 5, 6]. Though biodiesel has some attractive properties like higher cetane number, no aromatics, almost no sulphur, high oxygen(by weight), non-toxic, bio-degradable, high lubricant ability [7, 8, 9] it has many properties need to improve such as Lower Calorific Value (LCV), Lower Effective Engine Power (LEEP), NO_X emission, greater sensitivity to low temperature [9]. Biodiesel could be effectively used as substantial alternate fuel for the successful operation of diesel engine without any modification on it [13].

II. PRODUCTION OF BIODIESEL

A. Pretreating of the neat mahua oil - Filtering

The mahua oil is extracted from the seeds by the mechanized expeller. The extracted oil was very much translucent. Even though the oil is translucent, there are some residues of oil cake. These residues are separated out by filtering it. The filtration was done by the bag filters made from the canvas cloth. The oil was slightly heated before pouring into the bag. In around 24 hour all the residues settle down at the bottom of the filter.

B. Degumming

In this process the hydratable and non-hydratable phosphatides along with various resinous and mucilaginous materials are separated from the neat oil. The oil is treated with 3.5 to 4.5% of water at 62 to 75°C. The hydra table portions absorb water and became heavy and the heat helps to coagulate these smaller portions. The separation is achieved through difference in specific gravity, oil being lighter floated on top and gums being heavier settled down. The Non-hydra table portion is separated by increasing the phosphorous concentration by way of mixing with 0.13 % to 0.24 % of phosphoric acid.

C. Deodorization

In this process the odoriferous materials which are present in the oil are removed. The odoriferous materials are necessarily more volatile than glycerid components and this large difference in volatility has made steam distillation more feasible. The operation is carried out at elevated temperature of 196 to 204° C and at high vacuum of 12 torr, which enhances the volatility difference. The steam acts as a carrier. The high vacuum protected the hot oil from atmospheric oxidation and prevented the undue hydrolysis of oil by steam. Since all the Peroxides and Aldehydes are thoroughly removed during the steam distillation, the bio diesel is more stable for longer periods of time. During steam distillation, the free fatty acids are also distilled off. Deodorization is necessarily heating the oil to 196 to 204° under 12 torr vacuum and then sparging low pressure superheated steam through the oil for 4 hour till peroxide value is nil. After deodorization for 4 hour the Peroxide value became nil. The oil is then cooled to about 85°C and filtered. Citric acid (0.02%) is used as a chelating agent and as an antioxidant. This gives the oil a crystal clear appearance.

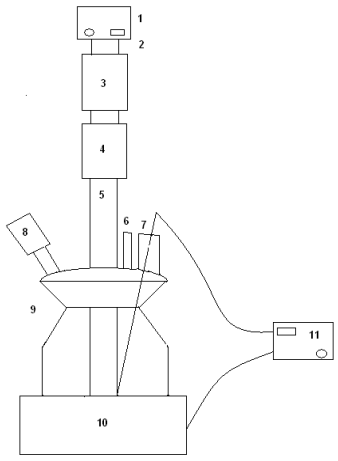
D. Process of removing the bitterness property

'Allyl Aldehyde'and 'Allyl Sulfide' are the two chemical constituents which are normally present in the vegetable oils make the taste of the oils to be bitter and they are separated from the neat oil by the process called 'Methanol washing' even before going for the Transesterification process. 6% (by volume for 1 lit. of oil) of the 85% methanol solution is added with the neat oil and thoroughly stirred. After some time of stirring, the bitter principles deposited at the bottom of the flask are separated out. This separation of the bitter principles becomes essential, since the separation of glycerin from the neat oil during the transesterification process would otherwise become very difficult.

E. Choosing the catalyst for the transesterification process

The Transesterification process has to be carried out in the presence of a catalyst. The selection of Catalyst is based on the pH value of the neat oil. If it is lesser than 7, acid catalyst should be selected and if it is greater than 7, base catalyst should be selected. The wrong selection of the catalyst leads to create soap formation. Since the pH value of the mahua oil is greater than 7, the researcher had used NaOH/KOH (base catalyst) as catalyst for the Transesterification process.

F. Production of biodiesel



1.Stirrer Motor, 2.Stirrer Rod, 3.Coupling, 4.Stirrer Lubricant reservoir, 5.Glass stirrer, 6.Funnel, 7.Thermocouple, 8.Water Condenser, 9.Glass Tank Reactor, 10.Heating Mantle, 11. PID Temperature controller

Figure 1 Biodiesel Production Setup

Figure 1 shows that biodiesel production set up. It can be produced by a two step acid-base process from raw mahua oil using methanol as reagent and H_2SO_4 and KOH as catalysts for acid and base reactions respectively. 15% of methanol mixed with 0.45% of H_2SO_4 acid by volume is prepared as acid solvent. Acid solvent is added to one liter of raw mahua oil with 60°C and stirring rate of 50 rpm for 45 minute for separating the residues of the solution. The final solution can be separated by using separating funnel. In the secondary step to prepare base process, 25% of methanol mixed with 0.85% of

KOH by volume solvent is prepared as base solvent. Base solvent is added to one liter of mahua oil which is derived from acid process, heated up to 64°C for 45 min. Final solution can be separated from the glycerol by separating funnel.

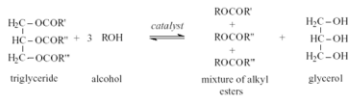
Table 1: Properties of Neat Diesel and Mahua biodiesel

S. No	Properties	Neat Diesel	Mahua Biodiesel
1	Density in kg/m^3	850	883
2	Specific Gravity	0.85	0.88
3	Kinematic Viscosity at 40°C	3.05	5.0
4	Calorific Value (ki/kg)	42,800	37, 500
5	Cetane Number	47	56
6	Flash Point in °C	85	170
7	Pour Point in °C	-4	-5
8	Cloud Point in °C	-2	-3

Table 1 shows that properties of neat diesel and mahua biodiesel. It is clear that specific gravity, kinematic viscosity, flash point and fire point increases for biodiesel as that of neat diesel. It is also observed that the flash point and fire point is slight more for biodiesel than that of neat diesel. Therefore biodiesel is very easy to store and safe for transportation as compared to neat diesel. The gross calorific value decreases for biodiesel as compared to neat diesel.

G. Washing of biodiesel

The final solution may be having some soap content. This may be removed by using the bubble washing by adding 50% of water with final solution which is derived from base reaction process. This solution may be heated up to 100°C for removing water content which is available in the solution. The biodiesel (mixture of alkyl esters) is the end product of this process. Equation 1 shows the chemical route of biodiesel production from mahua oil.



(1)

H. De-methanolisation of the biodiesel

After washing of the biodiesel, the excess methanol, if any, is evaporated by heating it to about 70°C (boiling point of methanol) for few minutes. This process is called as De-methanolisation.

III. CONCLUSIONS

Researchers have done the various experiments on the use of biodiesel in order to minimize the use of neat diesel and search of renewable, alternative fuel on diesel engine. The production of biodiesel from mahua is a new option for operation of diesel engine and could be efficiently used in diesel engine without any modification in the existence condition. In India, its better option to use biodiesel produced from mahua in order to overcome the problems related to neat diesel price increment.

REFERENCES

[1] Gerhard Knothe, "Biodiesel and Renewable diesel: A comparison", Progress in Energy and combustion science, vol. 36, pp. 364-373, 2010.

[2] Knothe G., Krahl J., Van Gerpen, J. editors. The biodiesel handbook, Champaign, IL, USA, 2005.

[3] A. C. Lloyd, and T. A. Cackette, "Diesel engine: environmental impact and control", J Air Waste Manage Assoc., vol. 51, pp. 809-47, 2001.

[4] M. Zheng, M. C. Mulenga, G. T. Reader, M. Wang, D. S. K. Ting, and J. Tjong, "Biodiesel engine performance and emissions in low temperature combustion", Fuel vol. 87(6), pp. 714-22, 2008.

[5] A. K. Agarwal, and K. Rajamanoharan, "Experimental investigation of performance and emissions of karanja oil and its blends in a single cylinder agricultural diesel engine", Applied Energy, vol. 86, pp. 106-12, 2009.

[6] Y. F. Lin, Y. P. G. Wu, and C. T. Chang, "Combustion characteristics of waste- oil produced biodiesel/diesel fuel blends", Fuel, vol. 86, pp. 1772-80, 2007.

[7] M. Canakci, "Combustion characteristics of a turbocharged decompression ignition engine fuelled with petroleum diesel fuel and biodiesel", Bioresource Technol vol. 98, pp. 1167-75, 2007.

[8] C. H. Lin, H. A. Lin, and L. B. Hung, "Fuel structure and properties of biodiesel produced by the peroxidation process", Fuel, vol. 85, pp. 1743-49, 2006.

[9] B. Kegl, "Biodiesel usage at low

temperature", Fuel, vol. 87(7), pp. 1306-17, 2008.

[10] R. G. Nelson, and M. D. Schroc, "Energetic and economic feasibility associated with the production, processing and conversion of beef tallow to a substitute diesel fuel", Biomass Bioenergy, vol. 30, pp. 584-91, 2006.

[11] Vishal Mutreja, Satnam Singh, and Amjad Ali, "Biodiesel from mutton fat using KOH impregnated MgO as heterogeneous catalyst'', Renewable Energy, vol. 36, pp. 2253-2258, 2011.

[12] B. K. Venkanna, C. Venkataramana Reddy, and Swati B. Wadawadagi, "Performance, emissions and combustion characteristics of DI diesel engine running on rice bran oil / diesel fuel blend", International Journal of chemical and biological engineering, vol. 2, pp. 3-11, 2009.

[13] C. Solaimuthu, V. Ganesan, D. Senthilkumar, and K. K. Ramasamy, "Experimental investigation of Emission reductions studies of a biodiesel engine using EGR and SCR for agriculture operations in developing countries", Applied Energy, vol. 138, pp. 91-98, 2015.

Authors Profile

P. Vetrivel, received the **B.E.** degree in Mechanical Engineering from the Sona College of Technology, Salem, Madras University, Chennai, India, in 2001.Currently doing **M.E.** in Thermal Engineering in Anna University, Chennai, India. His research interest includes biodiesel, biogas etc.,

Dr. C. Solaimuthu, received the **B.E.** degree in Mechanical Engineering from the Sona College of Technology, Salem, Madras University, Chennai, India, in 2001. **M. Tech** (Thermal Plane Engineering) degree from SASTRA University, Thanjavur, India, in 2004. and **Ph. D** (Biodiesel) from Anna University, Chennai, India in 2012. His research interest includes biodiesel, biogas, I.C Engines and CFD.