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Production and Characterisation of Biodiesel with the mixture of Ambadi oil and Waste Cooking Oil

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With the continuous global reduction of energy supplies and severe concern over environmental degradation with the use of fossil fuel, biodiesel will play a crucial transponder in these problems. Biodiesel blend with diesel fuel achieves a decreased environmental impact without losing quality of performance and use. There is interest in alternative fuels owing to volatile fossil fuel markets and degradation. New and alternative oil crops must be pursued to expand the horizon of plant-based fuels to satisfy the needs of energy demand. The purpose of this research was to compare the properties of ambadi seed oil biodiesel, waste cooking oil (WCO) biodiesel, and biodiesel of WCO ambadi seed oil mixer. The results of the study indicate that biodiesel with the introduction of WCO in Ambadi seed oil improves the physiochemical properties calorific value, flash point, and fire point. The blending of WCO limited upto AW50 due to increase in density and kinematic viscosity of biodiesel produced.

Keywords: Biodiesel, Catalyst KOH, Ambadi oil, Waste cooking oil (WCO)

1 Introduction

The availability of energy is the most important part of human life & being an essential input for every activity. Energy demand is rising steadily due to speedy increase in industrialization and automobile vehicles. The sources of this includes solid (coal, nuclear), liquid (petroleum fuel) & gases (natural gas). These sources are non-renewable energy sources. Fossil fuel, because it's of energy value density, economy, and chemical characteristics, still suitable for the primary transportation fuel and industrial and commercial feedstock[1]. Several other reports suggest that in 41 and 63 years oil and gas reserves are going to be depleted if consumption remains at a constant rate[2]. In the transportation sector, the use of petroleum and other liquid fuels continues to increase through 2050, but its consumption decreases due to the addition of alternating fuels, from 94% to about 82%[3]. The serious disadvantages of using fossil fuels are environmental pollution exhaust emissions. Carbon emission from fossil fuel has been reported to 98%. They emit large amounts of exhaust gases like NOx, CO & smoke which results in hazardous for human health[4].

Due to these impacts, people may catch various diseases, like lung cancer, breathing difficulties, poisoning etc. To overcome these concerns there is a requirement of controlling diesel engine emissions & future energy demands[5]. Exhaust emission of NOx to the environment was reduced up to 60% and smoke up to 29%, achieved by different blends of biodiesel with diesel in CI engine[6]. The biodiesel can be produced from both edible & non-edible vegetable oil. The use of bio-fuel in place of conventional fossil fuels reduces and slows down the global warming[7]. Several alternating fuels have been studied as a replacement to diesel fuel partially or completely. Various crops and plant seeds have been recognized for production of alternating source for fuel as biodiesel. Vegetable oils are suitable alternative diesel fossil fuel[4].The use of vegetable oil biodiesel as alternating fuel is also less expensive as compared to diesel[5,8,9]. A considerable number of researches have been carried out in this field to understand these issues of emission and operating characteristics of bio fuel[10,11].

In India, over 63 million hectare of land is not used for agriculture or any useful purpose. This unused land is unsuitable for cultivation; called "Waste lands"[12]. Currently waste lands cultivate bio-fuel crops like Jatropha, castor, Pongamia etc[13]. Although, these crops extend in divergent regional climatic conditions and nutrient obligators are critical. Due to these issues, there is reduced plantation of these types of plants in wastelands. Hibiscus cannabinus is the plants that belong to Malvaceae category; it is known

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by various common names like hemp, ambadi, Roselle, Jamaica sorrel[14]. Ambadi belongs to cotton family and it is kharif crop. It is suitable for the tropical and subtropical climatic regions. Ambadi crops plant area can have positive influence on its production and crop composition. To execute the medium range crop production, it requires nearly 8 kg/ha seeds. When the number of plant quantity lay 185000 /ha, stock production generally reduces[15]. If ambadi seeds are not stored in favourable climate, less oil content also affect the seed's feasibility. Preservation techniques should employed to conserve the feasibility, particularly for scrutinize/examining durable storage of seeds. Various states of India cultivate the ambadi crop viz, Gujarat, Andhra Pradesh, West Bengal, Rajasthan, Bihar, Maharashtra, *Karnataka,* Odisha, etc[16,17,18]. Conversely, since it contaminates the water system, there are issues involved with the recycling of used cooking oil. It is either disposed or used safely to be harmless for people[8]. It is therefore safe. The used cooking oil used is composed predominantly of short-chain saturated fatty acids. One of the attempts to recycle waste is the use of biodiesel feedstock and it is a much cheaper raw material[15]. Raw material prices and insufficient supply of vegetable oils are significant crucial problems for biodiesel manufacturing. Roughly 75% of the overall cost of production contributes to approximately 1.5 times higher costs than commercial diesel[19]. In the other hand, the price of cooking oil is 2-3 times cheaper than that of virgin vegetable oil, which will substantially lower the cost of making biodiesel[19]. There is a significant volume of output of waste cooking oils as food intake grows and the conversion of this waste cooking oil into fuel would also reduce the environmental impacts[20,21,22]. The Literature Review confirms the high-scale use of waste cooking oil in biodiesel processing.

Biodiesel production from the oil of non-edible vegetable crops seed can be obtained using four approaches viz blending, pyrolysis, transesterification and micro emulsification[23]. Transesterification approach has the benefits of minimizing the viscosity of oil and improving the chemical resources[24]. Numerous previous investigations have been made on increasing biodiesel properties using a certain mixture. The inclusion of cooking oil, for example, decreases the Ambadi oil's viscosity. This is how it modifies the composition of fatty acids, and this contributes to new effects. Biodiesel can depend on the composition of fatty acids to conform to a stated norm[25]. Bio-diesel produced from triglyceride dissolves in vegetable oil or animal fat reacted with alcohol that forms glycerol and methyl ester known as biodiesel[19]. Transesterification chemical process is carried out with help of one or more catalyst. Edible oils contain large amount of free fatty acid as compared to non-edible oils[23,26,27]. Due to a high fuel yield, ease of experimentation, and resemblance of the properties of the generated fuel to those of traditional diesel, this approach is adopted for the current work. Triglycerides react with alcohol, which may be methanol, ethanol, propanol, or butanol, during the transesterification of vegetable oil and are converted into monoglycerides. Because of its low cost, methanol is the most widely used alcohol.

Transesterification of non-edible using base catalyst results in high-quality biodiesel with less reaction time period. The yielding of biodiesel produced is reduced using base catalyst due to formation of soap[26]. The use of acid catalyst in the transesterification approach has the advantage of being resistant and less sensitive about elevated FFAs. The rate of reaction of transesterification process in the presence of an acid catalysts have slow[14,27]. Mixed vegetable oil developed a nonlinear composition consisting of fatty acids[28,29]. Post-treatment employed for purification of produced biodiesel to remove dissolved glycerol and sediment-water impurities[30]. Cow dung ash as an absorbent for removal of impurities in biodiesel from WCO, worked similar to water treatment[31]. Therefore, the purpose of this analysis has to ascertain the effect of the mixture of waste cooking oil on the properties of Ambadi seed oil. The different characteristics (density, viscosity, flash point, and calorific value) of produced biodiesel have analysed. The goal has also to evaluate the effect of how raw materials from biodiesel could be blended before and after transesterification.

2 Materials and Method

The approach for the proposed process can be categorised in three sub-sets: biodiesel extraction, purification and characterization. The present research was an experimental analysis on the application of biodiesel derived from ambadi seed oil of the second generation and its various blends with waste cooking oils. In the production of biodiesel from non edible vegetable crop, primary importance was the selection of crops. Whole production was based that selection and further biodiesel produced as per methodology Fig. 1

2.1 Oil material collection

Ambadi plant was waste crop on agriculture land; it has no utility for agriculture farmers. The seeds of Ambadi bio diesel production were purchased from local market (Fig. 2). The waste cooking oil (groround nut) obtained from the local restaurant was another oil used for the biodiesel production process. The KOH catalyst was pure grade obtained from the Friends Agency Bikaner, India. Certified methanol of 99.8% pure was purchased from Aryan Agency Bikaner, India.

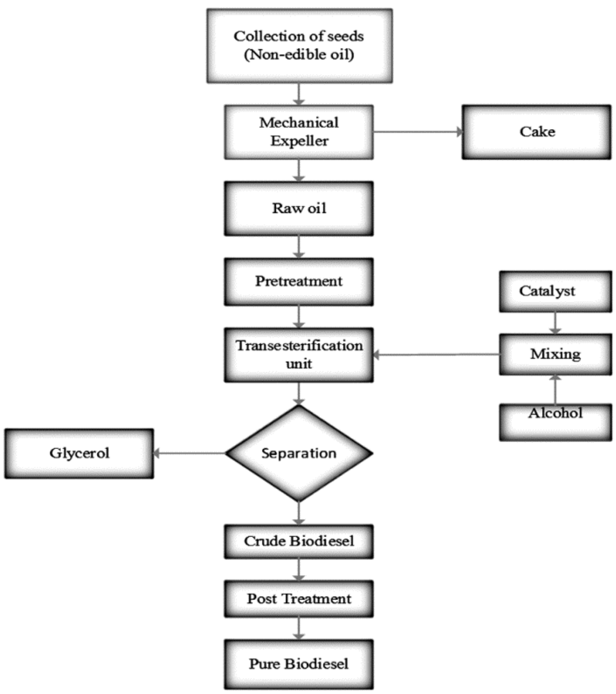


Fig. 1 — Schematic diagram for biodiesel production.

Fig. 2 — Ambadi seeds.

2.2 Transesterification of oil

Pre-treatment of oil

Pre-treatment was performed to eliminate impurities such as food particle remnants, solid impurities, and a higher proportion of moisture in the feedstock. The transesterification reaction may be adversely impacted by these impurities and could thus be removed. Filtering and dehydration were included in pretreatment. To remove the suspended food and solid particles, primary filtering was performed using a simple fabric filter. Secondary filtering, using filter paper, was achieved. At a temperature of 90°C, Ambadi and waste cooking oils were mixed for 60 minutes. A heater and stirrer were used for mixing as shown in Figs 3 & 4. Ambadi oil and waste cooking oil mixture compositional ratios were 100:0 to 50:50 with an improvement of 10 percent.

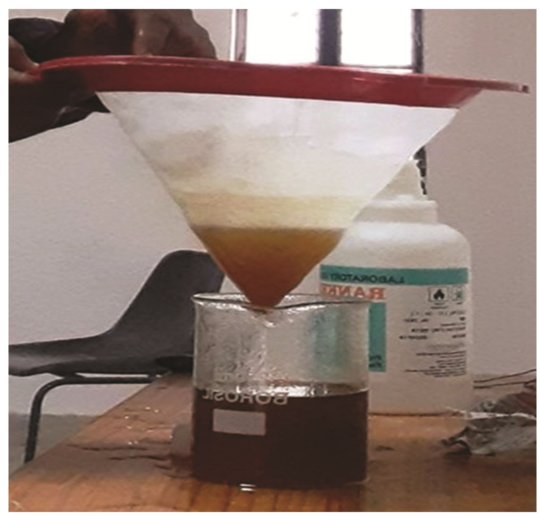
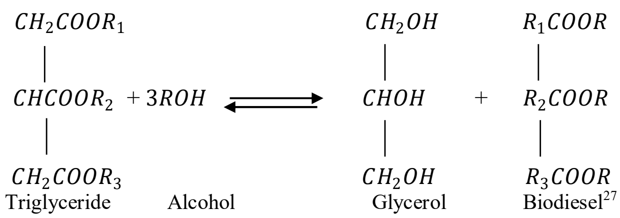


Fig. 3 — Pre-treatment of vegetable oil.

Fig. 4 — Pre-heating of vegetable oil.

2.3 Extraction of biodiesel

Different alcohols can be used in this process, including methanol, ethanol, propanol & butanol. The application of methanol was more feasible because of its low cost & physical as well as chemical advantages, such as being popular & having the shortest carbon chain. Methanol (10 percent of oil volume) and potassium hydroxide (KOH) were used for the transesterification process (1 percent of oil volume as the catalyst).At 60°C, the mixture was stirred for 60 minutes. The mixture was stored in the separator for around 8 hours after the transesterification process was finished, resulting in a distinction between biodiesel and glycerol, with the latter separated from the bottom layer. The reaction temperature was maintained at 60^{o}C, stirrer speed at 250 rpm & reaction time about 60 minutes. This whole process was repeated two times for improved accuracy and yield for biodiesel.



2.4 Separation and Post treatment

If this appropriate biodiesel processing method was formulated, the same methodology is followed for all the samples. For the removal of dissolved methanol and KOH, the biodiesels thus produced were subjected to water wash. By heating them to 105^{0}C, the water content in the biodiesel was removed as shown in Figs 5 & 6. In the thermal laboratory, Department of Mechanical Engineering, GEC, Bikaner, these experiments were carried out.

Fig. 5 — Ambadi biodiesel separation.

2.5 Biodiesel Characterization

Some of the essential properties were determined for validation according to particular requirements after biodiesel production. Using different methods and equipment, fuel properties such as density, kinematic viscosity, acid value, flash point, fire point, and calorific value, etc were measured. The relevant physicochemical properties were evaluated for biodiesel — densities, kinematic viscosity, acid value, flash point, fire point, cloud point, pour point, and calorific value. Table 1 presents the different methods and instruments used for the calculation of fuel properties.

3 Results and Discussion

3.1 Repeatability test for Biodiesel

To achieve better accuracy and quantity of biodiesel from the adopted production technique repeatability test was performed three times. The tests were performed with same transesterification working conditions as adopted earlier. Transesterification temperature was maintained 60°C for one hour while mechanical stirring at 800 rpm. Yielding of biodiesel was calculated after purification followed separation and post-treatment of triglyceride as shown in Table 2.

Average biodiesel yielding from the repeatability test (Table 2) was obtained. The maximum conversion of free fatty acid (FFA) vegetable oil to biodiesel was obtained from AW40 of 93 as shown in Table 3. The yielding of biodiesel mainly depends upon the catalyst concentration, molar ratio, etherification process temperature, and time.

3.2 Biodiesel characterisation observations

Production of biodiesel was carried out by using mechanical stirring with homogeneous catalyst KOH

Fig. 6 — Ambadi WCO biodiesel separation.

Table 1 — Different methods and instruments used for the calculation of fuel properties

Name of Chemical Property	Testing Method	Instrument	
		Type	Specification
Density at 15 ^{0}C, Kg/m3	lS1448(Part-16): 1990	Hydrometer	Short range 20 °C, Cal 0.001, Accuracy : ± 1 division
Kinematic Viscosity at 40 ^{0} C cSt	lS1448(Part-25): 1976	Redwood Viscometer digital	flow 20 seconds to 2000 seconds
Acid Value, mg KOH/gm	IS 1448 (Part-2) 2007	Total Acid Number Analyzer	Auto Single Burette Operation
Flash Point, ^{0}C	lS1448(Part-21):1992	Pensky-Martens Apparatus	Accuracy 0.1 ^{0}C
Cloud Point, ^{0}C	ASTM D 2500	MPP 5Gs Analyser	low temperature testing to -95°C
Pour Point, ^{0}C	ASTM D 97	MPP 5Gs Analyser	Accuracy 0.1 ^{0}C
Fire Point, ^{0}C	ASTM D 93	Pensky-Martens Apparatus	Accuracy 0.1 ^{0}C
Calorific Value, kcal/kg	ASTM D 4868	Automatic Bomb Calorimeter	GCV Range: Up to 10,000 Kcal

Table 2 — Results of Repeatability test for biodiesel

Repeatability test Number	Yielding of biodiesel					
	AO	AW50	AW40	AW30	AW20	AW10
1.	92	90	93	90	90	91
2.	93	91	92	91	89	93
3.	93	91	93	90	90	93

Table 3 —Yield of Biodiesel

Type of oil	Biodiesel Yielding (%)
AO	93
AW10	90
AW20	90
AW30	91
AW40	93
AW50	92

Table 4 — Physiochemical property and comparing with Bio-diesel standard

S. No.	Name of Chemical Property	Results							Biodiesel Standard IS15607:2016[32]
		Ambadi	AW50	s	AW30	AW20	AW10	WO	
1.	Density at 15 °C, kg/m^3	863.4	880.9	877	874	872	865.4	891.9	860-900
2.	Kinematic Viscosity at 40 °C cSt	4.01	4.65	4.54	4.40	4.24	4.07	4.93	3.50-5.0
4.	Acid Value, mg KOH/gm	0.49	0.48	0.48	0.49	0.49	0.49	0.47	0.50 max
5.	Flash Point, °C	105	173	158	147	128	120	180	101 min
6.	Cloud Point, °C	5	8	8	8	6	6	10	-
7.	Pour Point, ° C	-1	-0.98	-1	-1	-1	-1	-1	-
8.	Fire Point, ° C	112	183	168	157	135	117	192	
9.	Calorific Value, MJ/kg	35.647	36.92	36.70	36.45	36.15	36.05	37.435	-

from Ambadi and different blends AW10, AW20, AW30, AW40, AW50 of WCO with ambadi oil and processed through pre-treatment, transesterification and post-treatment. The suitability of biodiesels as alternating was checked by elaborating the physiochemical property and comparing it with biodiesel standards. Table 4 showed the properties of standard biodiesel fuel[32], B100 Ambadi biodiesel, and B100 waste cooking oil, AW10 AW20 AW30 AW40 and AW50. B100 Ambadi demonstrated a lower density, viscosity, flash point, fire point and calorific value than that of cooking oil, while its acid value was higher than that of waste cooking oil.

3.2.1 Density

The quantity of fuel mass that can be introduced into the combustion chamber is depending on the fuel density. In addition, the fuel-air ratio (AFR) and the energy content of the fuel entering the combustion chamber were influenced by the fuel density. The oil mixture's density is affected by the degree of unsaturation. The lower the degree of saturation, the greater the density of the oil[18]. Ambadi biodiesel was a density of 863.4 kg/m^3 . The density of biodiesel was predicated by using the following regression Eq.1 where X is % of AO in WCO

$$Calorific\ Value = 35.77 + 0.02290X \quad \ldots (1)$$

The lower density of biodiesel from Ambadi increases with the increasing mixture of biodiesel used for cooking oil as shown in Table 5 and Fig. 7 where S was known both as the standard error of the regression and as the standard error of the estimate and R-squared was a statistical measure of how close the data were to the fitted regression line. Mixer density linearly rises as waste cooking oil used percentage increases in ambadi seed oil.

3.2.2 Kinematic viscosity

Viscosity was a significant property since the capacity of the fuel sprayer is compromised. High viscosity induces greater particle size, sprayer constraint, and narrow-angle of injection of the

Table 5 — Density of different biodiesel samples

Biodiesel	Density at 15^0C(kg/m^3)	Uncertainty
AW10	865.4	±0.001
AW20	872	±0.001
AW30	874	±0.001
AW40	877	±0.001
AW50	880.9	±0.001

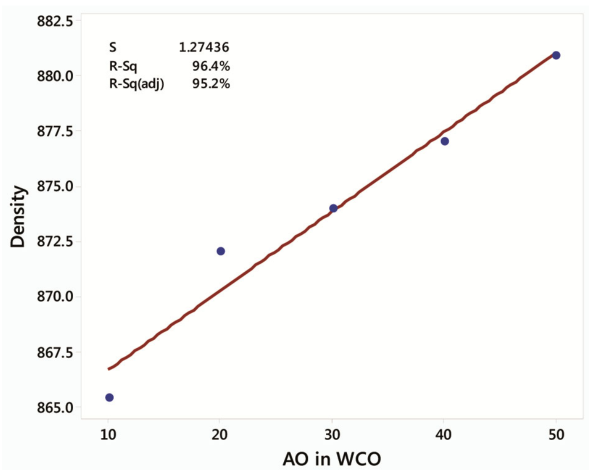


Fig. 7 — Variation of density with WCO in Ambadi Oil.

sprayer[20]. Viscosity was caused by the level of un-saturation and the long fatty acid chain. The kinematic viscosity of biodiesel was predicated on using regression Eq. 2 where X was % of AO in WCO-

$$Kinematic\ Viscosity = 3.9420 + 0.014600\,X \quad \ldots (2)$$

Measuring the accuracy of viscosity using an instrument was ±3 °C for biodiesel samples. Ambadi oil biodiesel showed a relative viscosity of 4.01 cSt at 40 °C as shown in Fig. 8. This was due to the fatty acid of the ambadi oil.

3.2.3 Calorific value

The typical calculation of energy content was calorific value, which was lower in vegetable oil than it in diesel due to high oxygen content. Biodiesel's low calorific value reduces engine power and, as a result, raises the consumption of fuel. The higher content of double bonded fatty acids in the carbon chain (C=C) decreased the caloric benefit of biodiesel[18].

The calorific value of biodiesel predicated by using regression Eq. 3 where X was % of AO in WCO-

$$Calorific\ Value = 35.77 + 0.02290\,X \quad \ldots (3)$$

Biodiesel from waste cooking oil was a higher calorific value (37.43 MJ/kg) than that of Ambadi oil (35.67 MJ/kg) owing to higher double bond fatty acids in ambadi seed oil biodiesel as shown in Fig. 9 and Table 6. A higher calorific value was found with

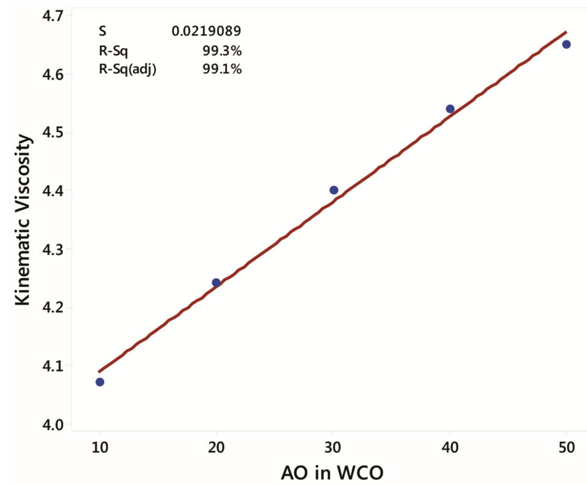


Fig. 8 — Variation of Kinematic viscosity with WCO in Ambadi Oil.

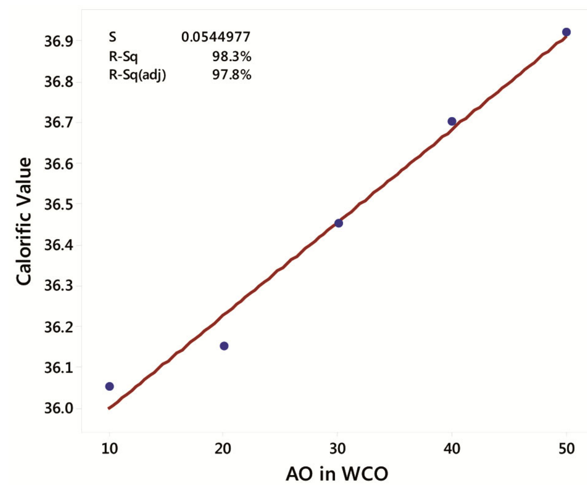


Fig. 9 — Variation of Calorific Value with WCO in Ambadi Oil.

biodiesel mixed with waste cooking oil. Because of improvements in their structure, the blended biodiesel of Ambadi seed and waste cooking oil improved the calorific value.

3.2.4 Flash point and Fire point

The flashpoint was the lowest temperature at which oil provides quite enough vapour, which forms combustible mixtures when combined with air and gives a transitory flash when a tiny pilot flame was introduced. The fire point was a flashpoint extension that represents the situations in which vapour burns for at least 5 seconds on a regular basis. The fire point was usually higher than the flash point. The flash point and fire point of biodiesel predicated by using regression Eqs.4-5 where X was % of AO in WCO-

$$Fire\ Point = 102.50 + 1.650\,X \quad \ldots (4)$$

$$Flash\ Point = 104.40 + 1.3600\,X \quad \ldots (5)$$

Table 6 — Calorific Value of biodiesel samples

Biodiesel	Calorific Value(MJ/kg)	Uncertainty
AW10	36.05	±0.003
AW20	36.15	±0.003
AW30	36.45	±0.003
AW40	36.70	±0.003
AW50	36.92	±0.003

Table 7 — Comparison of Fire and flash point of biodiesel samples

Biodiesel	Fire Point (°C)	Flash Point (°C)	Uncertainty
AW10	117	120	±0.02
AW20	135	128	±0.02
AW30	157	147	±0.02
AW40	168	158	±0.02
AW50	183	173	±0.02

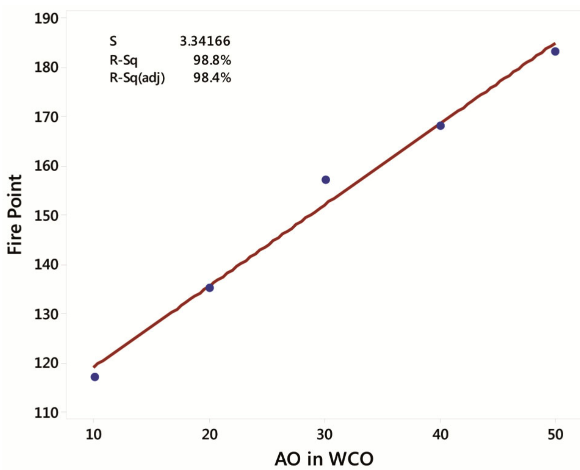


Fig. 10 — Variation of Fire Point with WCO in Ambadi Oil.

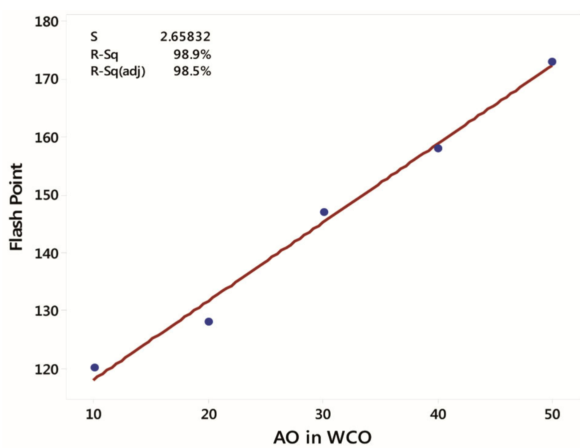


Fig. 11 — Variation of Flash Point with WCO in Ambadi Oil.

The flashpoint and fire point of waste cooking oil biodiesel were higher than that of ambadi seed oil biodiesel as shown in Table 7 while the flashpoint of ambadi seed oil biodiesel was 105°C and fire point 112°C. Biodiesel obtained by mixing waste cooking oil and ambadi seed oil raises the flash point and fire point, as shown in Figs 10 & 11.

4 Conclusions

In this study, biodiesel have produced from nonedible ambadi seed oil and waste cooking oil. Ambadi and waste cooking oil have different fatty acid structures, and this influenced the mixed biodiesel properties. The homogenous transeterifiaction process has used to convert Free fatty acid oil to biodiesel (methyl ester). The benefit of this process of biodiesel production has less reaction temperature and time duration. The maximum methyl ester conversion (93%) has achieved by AW40 (Ambadi oil with 40% WCO). The physical and chemical properties of different produced biodiesels have analysed. The result shows that there was increase in density, kinematic viscosity, fire point, and flash point obtained with increasing WCO in ambadi oil. The results also indicate that the calorific value increased with an increase in waste cooking oil percentage. The improvement in Calorific value indicates ambadi seed oil with WCO as alternating oil to fossil fuel. There has a linear increase in density and viscosity of ambadi and WCO which limits up to AW50.

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