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Research Article

EFFECT OF CATALYST IN CONVERSION OF BIO DIESEL FROM WASTE CHICKEN FAT

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ABSTRACT

In this present investigation waste chicken fat was used as a feed stock to develop the biodiesel. Two step esterification process was used to develop the biodiesel. Methanol and sulphuric acid was used in first step process and methanol and potassium hydroxide (KOH) was used in second step esterification process. Properties of the biodiesel were obtained within the ASTM standards. The effect of methanol to fat ratio and reaction time on Acid value was determined during the first step esterification and also the effect of methanol to fat ratio, reaction time and catalyst concentration on conversion efficiency was found during the second step esterification process. Low Acid value was found at 0.2 methanol to fat ratio and 60^o C reaction temperature and high conversion efficiency achieved at 0.2 methanol to fat ratio, 60^o C reaction temperature and 0.7% of catalyst concentration.

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INTRODUCTION

In 1895, Rudolf Diesel developed a new engine with the intention that it could use a variety of fuels, including vegetable oil (peanut oil), when he showcased it to the public at the 1900 in Paris. But the diesel engine became more widely adopted in subsequent years, because petroleum-based diesel fuel proved to be less expensive and became the fuel of choice.

However in 21st century investigations on renewable energy resources are continuing extensively due to increasing dependence on petroleum products. Besides, the combustion of petroleum based fuels causes environmental problems, which threaten wild and human life. The global warming is caused of emissions like carbon monoxide (CO₂), sulphur dioxide (SO₂) and nitrogen oxides (NO_x). Concerning environmental damage the transport sector has a clear responsibility. So many researches has been conducted in worldwide to these problems and found that Biodiesel is one of the most renewable energy sources for diesel engines. Biodiesels are produced from vegetables oils or animal fats having very long alkyl esters. However the vegetable oils and animal fats cannot be used directly in diesel engines due to their inappropriate properties such as longer molecule chains, lower vapor pressures, higher viscosities and higher flash points. These features cause poor atomization, poor vapor-air mixing, low pressure, and incomplete combustion and engine deposits. However, it is

possible to reduce the viscosity and improving the physical features of both vegetable oils and animal fats through dilution, Pyrolysis, micro emulsion and esterification [9]. Esterification is a kind of catalytic reaction in which oil or fat is reacted with alcohol to form esters (biodiesel).which can be used in conventional diesel engines without significant modifications. Using of biodiesel blends in diesel engines emissions will be reduced to greater extent listed in table 1

Variety of vegetable oils are used in production of biodiesels. These esters have certain advantages such as lower viscosity, lower flash point, and higher vapor pressure and easier processing relative to animal fatty acid esters, but they are noneconomic and non-feasible due to their prohibitive cost. Furthermore, many vegetable oils used in the production of biodiesel are edible oils and hence are valuable and it leads to food shortages. On the other hand, Biodiesel may also be produced from fats, including inedible tallow, pork lard and yellow grease. These are in human food leads to health hazards. This is one of the reasons for their low cost. Besides, their high cetane number and heating values are close to the diesel fuel and their oxygen content make animal fats to have surplus advantages [12]. Animal fats are highly viscous and mostly in solid form at ambient temperature because of their high content of saturated fatty acids. The high viscous fuels lead to poor atomization of the fuel and result in incomplete combustion. Trans esterification and emulsification are two main solutions

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that have appeared as effective methods for using animal fats in diesel engine. Animal fat generated biodiesel offers a wide range of energy, environmental, and economic advantages as stated by Nelson and Schrock [14].

In this study, a substitute fuel for diesel engines was produced from waste chicken fat, collected from a local slaughterhouse during meat preparation process.

Process and Methods

Initially chicken fat was heated to 100°C for 1 hours and sediments and impurities were removed using filter. Then the properties of the fat were determined shown in table 2. It consists of higher Acid value 28.2 mg KOH/g fat; Free Fatty Acid (FFA) content is 14.1%. Oils or fats having FFA content more than 3% is difficult convert as Bio diesels using base or Alkaline esterification alone. So it has to undergo pretreatment called as Acid esterification followed by the Base esterification.

Table 1 Average Biodiesel emissions compared to conventional diesel

Emission type		B100	B20
Regulated	Total unburned hydrocarbons	-67%	-20%
	Carbon monoxide	-47%	-12%
	Particulate matter	+10%	+2%
	NOx		
Non Regulated	Sulphates	-100%	-20%
	PAH(Polycyclic Aromatic Hydrocarbons)	-80%	-13%
	n PAH(nitrated PAH)	-90%	-50%
	Ozone potential of speciated H	-50%	-10%

Source: National Biodiesel Board

Table 2 properties of Chicken fat

Property	value
Specific Gravity	0.91
Viscosity mm ² /s at 40 °C	39.2
Flash point (°C)	290 °C
Fire point	305 °C
Acid value mg KOH/g fat	28.2

Acid Esterification

In Acid esterification process sulphuric acid and methanol were used for reaction. Experiment was conducted at 60±2°C. Reaction temperature with different reaction times (30 min, 60 min and 90 min) and different methanol to fat ratio (0.1, 0.15, 0.2, 0.25 and 0.3v/v) at constant catalyst to fat ratio 0.7v/v. Then the mixture was transferred to separate funnel and allowed to settle for 12 hours. The top product was separated and FFA value was determined. It was less than 3%, so this product used for base esterification.

Base Esterification

In Base esterification methanol and KOH were used for reaction. Experiment was conducted at 60±2°C. Reaction temperature with different reaction times (30 min, 60 min and 90 min), different methanol to fat ratios (0.1, 0.15, 0.2, 0.25 and 0.3v/v) and different catalyst concentration (0.3%, 0.5%, 0.7%, 1.0% w/w).

Then the mixture was transferred to separate funnel and allowed for 12 hours to settle. Two layers were formed shown

in fig 1, top layer was the Bio diesel and bottom layer was the glycerin. Then bio diesel was separated from glycerin.



Fig 1 After Base esterification

Then the final bio diesel sent for water wash. The purpose of water wash is to remove un-reacted alcohol, catalyst, or glycerin in the biodiesel. Un-reacted alcohol decreases the flashpoint of biodiesel. Biodiesel with 0.2% alcohol does not meet ASTM fuel standards. Water wash reduces alcohol levels below 0.2% and also remove any soap or gel in the biodiesel. Mixture separated and formed two layers, at bottom milky water and biodiesel at the top. Then bio diesel is separated and same procedure was repeated about 4 to 5 times, each and every step the milkiness of water coming down shown in Fig 2,3,4.

RESULTS AND DISCUSSION

Acid Esterification

Various operating parameters like reaction time, reaction temperature, methanol to fat ratio etc will affect on reaction. And FFA value of the product described below.

Effect of Methanol to Fat Ratio

The molar ratio of methanol required as per stoichiometric ratio is 3:1, but practically more amount of methanol is required to have the complete reaction. Found that methanol to fat ratios in between 0.1 to 0.2 gives higher acid value due to incomplete reaction. At methanol to fat ratio 0.2 gives the FFA value less than 3% and slightly reducing with increasing the methanol quantity shown in fig 5, but to achieve complete alkaline esterification 3% of FFA value enough. So 0.2 (v/v) methanol to fat ratio is selected as optimum value.

Reaction Time

The effect of reaction time on FFA value was studied at 3 different reaction time at constant methanol to fat ratio 0.2 v/v. Found that reaction time at 30 minutes gives higher acid value, and at 60 minutes gives the less acid value, further increases acid value is decreasing slightly shown in Fig 5, so 60 minutes reaction time is taken as optimum reaction time.

Base Esterification

The product of acid esterification which is having FFA less than 3% is used for alkaline esterification in the presence of Base catalyst KOH and methanol. The effect of various operating parameters like reaction time, methanol to fat ratio and catalyst to fat ratio were determined to constant reaction temperature $60 \pm 2^\circ\text{C}$.



Fig 2 After first water wash

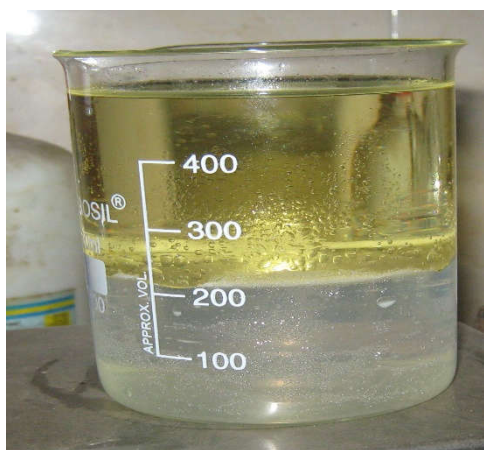


Fig 3 After third water washes

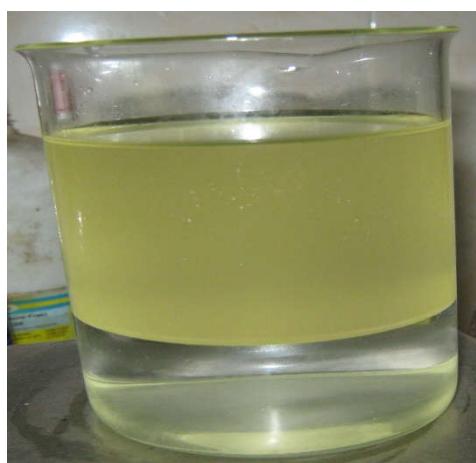


Fig 4 After fifth water washes

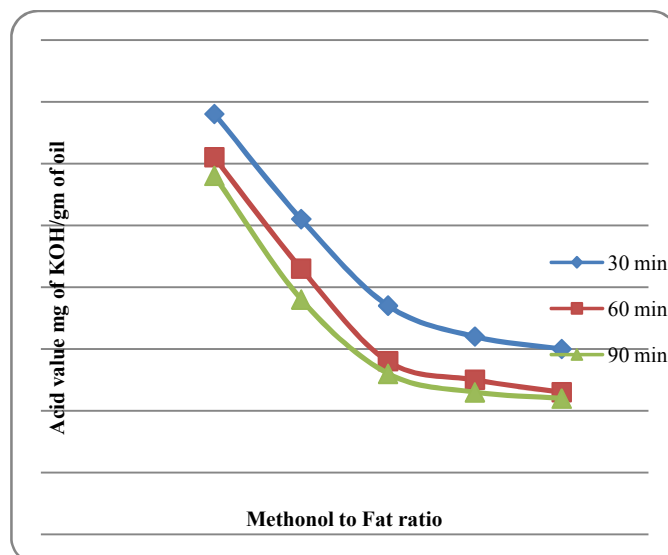


Fig 5 Effect of methanol to fat (v/v) ratio and reaction time on reduction of Acid value of Chicken fat at catalyst concentration 0.7% and reaction temperature $60 \pm 2^\circ\text{C}$

Effect of Methanol to Fat Ratio

Experimental results shown that methanol to oil ratio at 0.1 and 0.15 gives less conversion efficiency due to incomplete reaction, at 0.2 methanol to fat ratio gives maximum conversion efficiency of 83%, but further increasing the methanol efficiency increases very slightly shown in fig 6. So 0.2v/v methanol to fat ratio is taken as optimum value.

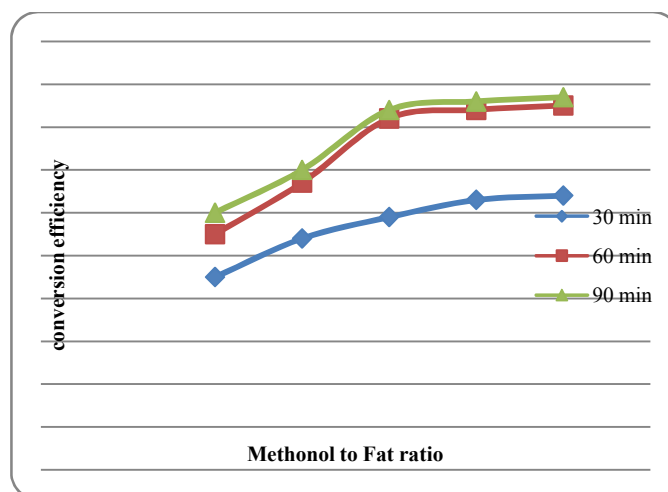


Fig 6 Effect of methanol to fat ratio and reaction time on conversion efficiency at catalyst concentration 0.7% and reaction temperature $60 \pm 2^\circ\text{C}$

Effect of Reaction Time

Experiment results shown that reaction time at 30 minutes efficiency is very less, but increasing the time conversion efficiency increases, at 60 minutes gives the maximum conversion efficiency, further increasing the time conversion efficiency is not increasing significantly shown in fig 6, so 60 minutes reaction time is taken as optimum value.

Effect of Catalyst

Experiment was conducted at different catalyst concentrations (0.3%, 0.5%, 0.7% and 1%w/w ratio). Experiment results shown that conversion efficiency increases with increasing catalyst concentration up to 0.7% shown in Fig 7. Further

increasing the conversion efficiency decreases due to more soap or gel formation which increase viscosity. So 0.7% of catalyst concentration is taken as optimum value.

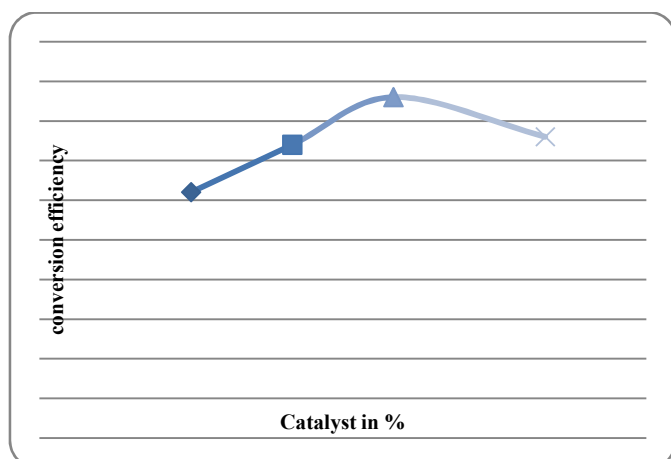


Fig 7 Effect of catalyst concentration on conversion efficiency

Characterization of Bio Diesel

Various properties of the bio diesel like specific gravity, flash and fire points, cloud and pour points, viscosity, calorific value has been found within the ASTM standards listed in table 3. The results suggested that the two step esterification process could be feasible and effective method to convert chicken fat as high quality bio diesel.

Table 3 Properties of Pure Biodiesel

Property	Testing procedure	Biodiesel standard ASTM 6751-02	Chicken fat biodiesel	Petroleum diesel
Specific Gravity	ASTM D4052	0.87-0.9	0.879	0.83
Calorific value MJ/kg	ASTM D240	-	38.45	43.5
Viscosity mm ² /s at 40 0C	ASTM D445	1.9-6.0	4.73	2.87
Flash point (0C)	ASTM D93	min. 130	176	46
Fire point	ASTM D 93	-	186	56
Cloud point	D2500	-3 to 15	-2	-1
Pour point	D2500	-15 to 10	-3	-16
Acid value mg KOH/g fat	ASTM D974	0.8	0.6	-

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CONCLUSION

Experiment results shown that conversion efficiency increases with increasing catalyst concentration up to 0.7% due to gel formation less. Increasing the time conversion efficiency at 60 minutes and it gives the maximum conversion efficiency due to take reaction time. The results suggested that the two step esterification process could be feasible and effective method to convert chicken fat as high quality bio diesel

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