11. BIODIESEL FROM MUTTON SUET

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ABSTRACT:

Biodiesel is considered as one of the most suitable alternative biofuel because of its self-sustaining nature and renewability, thereby making it an eco-friendly fuel. This nontoxic biofuel has replaced the existing fuel for combustion ignition engines with or without slight modifications. This combustion based applications makes the experts to study the fuel's engine performance, combustion and emission characteristics which varies accordingly for various biodiesel produced from different feedstock. This paper deals with production of biodiesel from the mutton suet and study related to its physiochemical properties and engine based combustion characteristics. Maximum fat content available in mutton suet was 96% out of which maximum achievable was 92% using autoclave heat extraction with FFA content of 0.5% .Most optimized parameters for transesterification reaction was 1:3 molar ratio, 2% catalyst concentration, reaction temperature of 60oC for 120 minutes which yielded 93%. The physicochemical properties showed better results than conventional diesel and were lying in the range prescribed by standard norms. The performance emission and combustion characteristics were studied and reported

SCOPE OF RESEARCH /NEED OF THE STUDY

The increase in power demand to meet the requirement of the expanding population has landed up the energy sector to produce more power to satisfy the demand. As the demand is being met, still there is shortage of power which leads to the limited supply of power from grid to user called "load Shedding". This action has not only affected the normal life of the people but

also affected the economy growth. The power shortage can be compensated by providing the additional power produced from various renewable sources like windfall and solar farms. But, the fluctuations in power generation from these sources have proved to be hopeless.

The solution for solving this complex situation is by considering the conventional technique with the aid of renewable energy resources. Identifying such a type of resource directs the pathway to bio fuels. The most prominent fuel among biofuels is bio diesel. These biodiesel are produced by Trans- esterification of oil/fats with alcohol in presence of acid/base catalyst. Generally the oil used for this purpose is obtained from plant seeds or vegetables and at some times from animal fats like fish fats. But the problem associated with the terms of edibility restricts the use of vegetable oils for this purpose. This issue stand as a hindrance for the implementation of full scale biodiesel technology.

The other serious problem faced is the disposal of animal wastes, which has been disposed from leather fleshing and slaughter houses. Direct disposal of this waste into environment causes harmful effects to humans and animals. Thus various problem related to disposal and handling arises which makes this issues more complex. But these animal wastes have very good fat content which can be used as a substitute for these edible oils. These fats have same characteristic properties like of the oil and can be promising. Thus by employing the concept of “waste to energy “,this work deals with the extraction of biodiesel and bio hydrogen from the animal fat extracted from the waste and thereby analysing, evaluating and implementing it for real time applications.

AIM AND OBJECTIVES

The following are the aims and objectives of this project:

1. **Identify a feasible method for extraction of lipids (fats) from the animal wastes:** Since the animal wastes consists a cluster of lipids, proteins and nitrogenous compounds, an optimum method must be identified to extract maximum amount of fat from it with less residues.

2. **Optimize the parameters for an effective trans-esterification reaction:** The extraction of biodiesel from animal fat is a long way process which are influenced by various parameters like molar ratio, temperature, stirring speed, viscosity, amount and type of catalyst. These parameters are linked with each other and have great impact in biodiesel production.

3. **Evaluate the performance and emission characteristics of the Biodiesel:** The extracted diesel must be analyzed using GC-MS analysis and the performance of the biodiesel must be carried. The comparison in performance of biodiesel with petro diesel will be done to identify the degree of superiority. Also the emission characteristics will be investigated by testing it on diesel engine.

DELIVERABLES OF THE STUDY

1. Understand the basic concept of fats, phospholipids and various methods involved in the extraction of the fat from animal waste**.**

2. Implement a very feasible and cost effective method for biodiesel production optimizing all the parameters

3. Obtain biodiesel from the animal waste as feed stock and perform various physiochemical test, performance evaluation and emission characteristics

INTRODUCTION

ANIMAL FATS

Animal fats and oils are lipid materials derived from animals. Fats are the most prevalent class of compounds (in living systems) referred to as lipids. Lipids are cellular compounds that are insoluble in water. Fats are soft, low-melting solids, with a density less than that of water. They have a greasy feel and are slippery. Fats and closely related oils are mixtures of compounds consisting of fatty acids combined with glycerol (commonly known as glycerin) via ester linkages. Fatty acids are long, straight chain carboxylic acids. A fat (or oil) is formed when three fatty acid molecules react with a glycerol molecule to yield a triglyceride.

Fat molecules are characterized as monoglycerides, diglycerides, or triglycerides, depending on whether there are one, two, or three fatty acid chains present in the molecules. Fatty acids in nature generally have an even number of carbon atoms because they are synthesized in cells via successive additions of two-carbon acetate groups in a stepwise cyclic reaction. Monoglycerides and diglycerides are metabolic intermediates and don't appear in large concentrations.

One fatty acid (acyl) group + glycerol: and are called monoacylglycerol or monoglycerides

Two fatty acid (acyl) groups + glycerol: and are called diacylglycerol or diglycerides

Three fatty acid (acyl) groups + glycerol: and are called triacylglycerol or triglycerides

Free fatty acids (FFA) are produced by the hydrolysis of oils and fats. The level of FFA depends on time, temperature and moisture content because the oils and fats are exposed to various environments such as storage, processing, heating or frying. Since FFA is less stable than neutral oil, they are more prone to oxidation and to turning rancid. Thus, FFA is a key feature linked with the quality and commercial value of oils and fats.

SOURCES FOR BIODIESEL

The animal fat has been identified as the alternate source for the biodiesel feed stock. But in many countries animal fat is treated as edible except fats obtained from few organs and body parts. So in order to avoid confusion and the problem related to edibility the fat which is treated to harmful and non-edible is considered as feedstock for biodiesel production. The two major sources for these fats are

a. Animal slaughter house (many internal organs which has very high fat content is discarded and thrown as waste ,which causes a serious environmental problem related to decomposing etc.)
b. Fleshing from leather waste (55% of solid waste generated form Leather Company has been generated from fleshing which is rich in fat and protein. The wastes are generated mainly from trimming, pre-fleshing, fleshing and shaving. These fleshing waste causes choking and treatment problems in CETP, this can be reduced by converting these waste into useful product).

MATERIALS AND METHODOLOGY

Extraction of fat: The collected samples were soaked in the water for 12 hours before it was neutralized with boric acid in order to reduce the pH concentration from 10 to 7.After neutralization, the animal wastes were autoclaved at 15 bar and 120oC.This made the fat to get separated from other non-fatty residues and float on top. These fats were then collected and heated at 60oC to remove the residues carried along with the fat.

Degumming of fat: The phospholipids present in the fat were removed by the means of degumming. In this process, ortho phosphoric acid of 1% of oil content was stirred with fat for 10 minutes at 250 rpm and was subjected for prolonged heating for another 10 minutes. The phospholipids were settled at the bottom as lecithin in form of dark brown residue.

Glycerolysis of Fat: The concentration of free fatty acids was identified by the means of FFA titration. the reduction in FFA% was achieved by the means of glycerolysis .The fat was mixed with glycerol in the ratio for various molar ratios ranging from 1:1 to 1:2.5 for various reaction temperatures and time with constant stirring speed. After the completion of reaction, the glycerol dissolved with water present in fat was settled at the bottom while the fat was at the top.

Transesterification of Fat: The pretreated fat was subjected to transesterification reaction for biodiesel production. The reaction was optimized by varying the molar ratio between 1:1 to 1:6, for various catalyst concentrations from 0.1 to 2.0 % at temperature operating between 50oC and 70oC. The reaction mixture was then subjected for separation using separating funnel.

Refining of Fatty Acid Methyl Ester: After separation, the layer at the top was found to be biodiesel whereas the layer at the bottom was glycerol. The separated fame was initially cleaned with the residual glycerol obtained as the by-product of glycerolysis by stirring it with 20

minutes to remove any residual glycerol present in it. After glycerol treatment the refined fame was subjected to water washing at 60oC for 15mins. After washing the mixture was allowed to settle down for 24 hours where the refined FAME was obtained. The FAME was heated for 110oC to remove any moisture content from it.

Refining of glycerol: The glycerol obtained as the end byproduct of transesterification reaction was taken along with the glycerol resulted as the residue after the refining of FAME was acidified by adding 31.45% of hydrochloric acid to reduce the pH below 1.After removing the impurities, the glycerol was neutralized with sodium hydroxide and was heated at 110oC to remove moisture content. The heated glycerol was mixed with 4 times its quantity of methanol to decolorize it. Finally the methanol was removed from the glycerol by means of distillation leaving behind pure glycerol.

Analysis of fuel properties: the various properties of the refined fame were analyzed using various instruments like flash and fire point device, redwood viscometer, bomb calorimeter etc.

Performance and emission characteristics: the biodiesel was blended with ordinary diesel in various blends of b10,b20 and b30.these blended fuels were tested on the test engine. The technical specifications of the test engine are given below:

COMPOSITION OF FATS AND OILS IN MUTTON SUET:

Fat and oil glyceride molecules can contain a single fatty acid species or any combination of up to three fatty acids. Most naturally occurring fat and oil molecules contain a combination of fatty acids. The greater the percentages of carbon-carbon bonds that are double bonds in the fatty acids of a glyceride, the lower is the melting point and the more likely the glyceride will exist as

a liquid at the ordinary ambient temperature. But animal fats exist in solid form even at ordinary conditions.

MUTTON SUET FAT DISTRUBUTION:

Table 2 Fatty acid distribution of animal fats

	Fatty Acid Distribution (% by weight)							
Product	**C14:0**	**C16:0**	**C16:1**	**C18:0**	**C18:1**	**C18:1**	**C18:3**	**Saturation levels**
	Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic	
Adipose Tissue	1–2	28–30	–	12–18	40–50	7–13	–	41–50
Subcutaneous Fat	3–6	24–32	–	20–25	37–43	2–3	–	47–63

CHEMISTRY OF MUTTON SUET

The extracted fat is combination of fats from various sources. There is heterogeneity in the composition of the fatty acids present in it. The most dominant fatty acids present in all the fats are:

Table 3 Dominant Fatty Acids in Mutton Suet

Saturated Fatty Acids	**Unsaturated Fatty Acids**
Lauric acid	Myristoleic acid
Myristic acid	Palmitoleic acid
Palmitic acid	Oleic acid
Stearic acid	Linoleic acid
	Linolenic acid

These fats and their concentrations vary for different sources. The most dominant fatty acid in most of the animal fats is Palmitic acid. Similarly the two major fatty acids in fish oil are oleic acid and Palmitic acid. Various compositions of fatty acids for different animal fats are tabulated below:

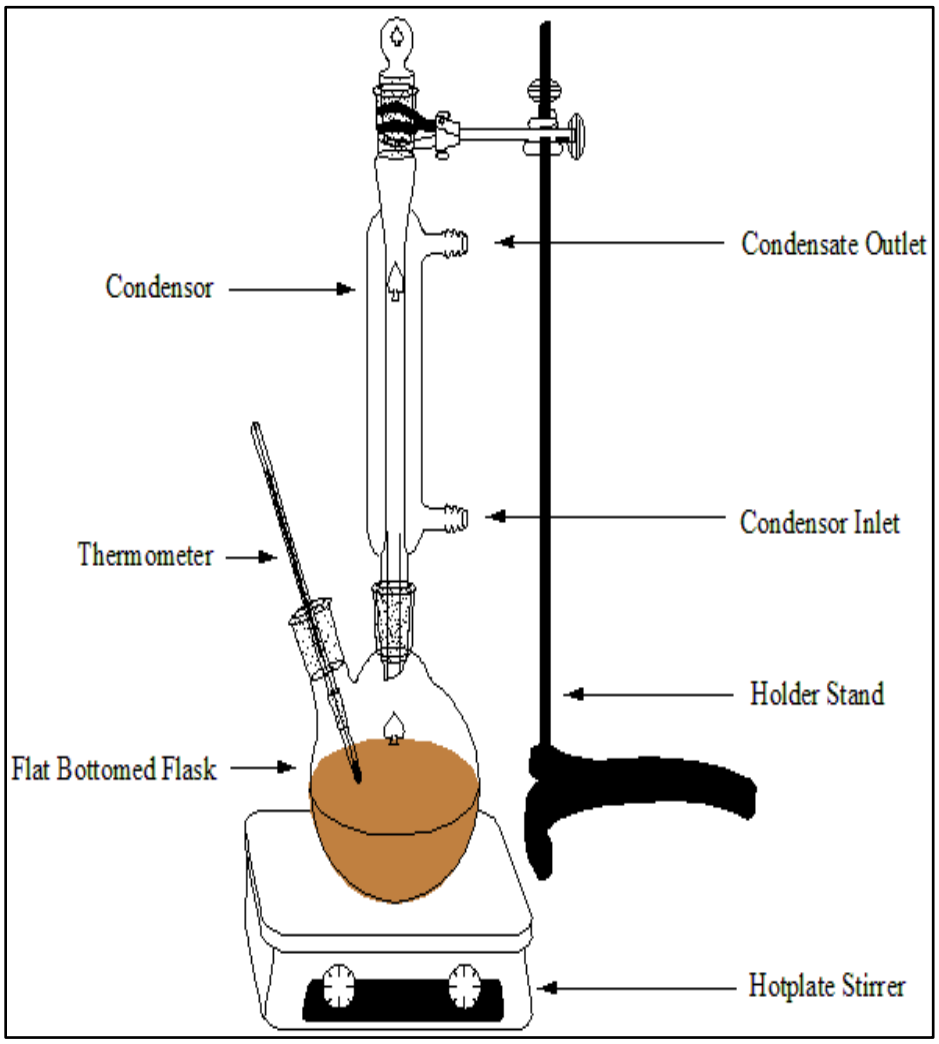
Table 4 Properties of Different Animal Fats

	C atoms	**Subcutaneous fat**	**Adipose Fat**
Melting point (^{o}C)		40-50	23-40
Iodine value		25-45	65-75
Myristic acid	2-3	1-1.5	
Palmitic acid	16	24-28	20-24
Stearic acid	18	20-24	4-6
Saturated fatty acids (%)		46-55	25-31.5
Palmitoleic acid	16	2-3	5-9
Oleic acid	18	40-43	33-44
Linoleic acid	18	2-4	18-20
Linolenic acid	18	<1	1-2
Unsaturated fatty acids (%)		45-51	57-75

The below table represents a short overview of how the fatty acid profile can be different in different parts of mutton. Different fatty acids are present in different parts of an animal which give rise to the combination of various fatty acids in a single tallow.

Here the same fatty acids from various sources combine with each other thus forming a uniform fatty acid chain whereas the isolated one give rise to new fatty acid. Thus when this fat sample is subjected for GC-MS testing, it gives rise to various peaks corresponding to the fatty acids depending upon its magnitude. The combining of same fatty acids from various feed stock can be noted from the peak which shows a single peak value instead of multi peak value indicating the same fatty acid. The uncombined fatty acids give rise to new peaks.

EXPERIMENTAL SETUP OF TRANSESTERIFICATION SETUP



APPARATUS SPECIFICATION

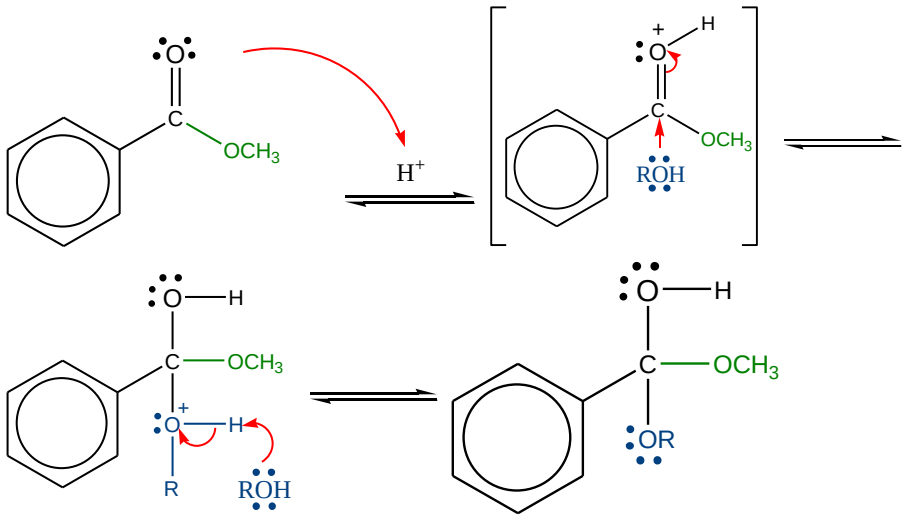
Model	2MLH
Stirring Capacity	2 Ltrs
Heating Capacity	300 watts
External Dimensions	200 x 225 x 185 mm
Stirring Paddle	PTFE Coated
Model	Q-19A
Length	9 x 35 mm
Maximum Stirring Speed	1200 RPM
Maximum Temperature	120^{o}C
Salient Features	• PMDC motor for higher torque even at low speeds • Better speed regulation even with small volume and low speeds • Accurate step less speed control maintains excellent speed stability. • Digital Speed Indicator for displaying of stirring speed • Totally enclosed unit • Designed for use even in corrosive atmosphere
Glassware name	Liebig Condensers
Overall H (cm)	40
S.T. Joints	24/40
Standard Product No.	Z531014

Transesterification Mechanism (Working Principle)

First half: Acid catalyzed addition of nucleophile

Step 1: protonation of Carbonyl Step 2: Nucleophile Attack Step 3:

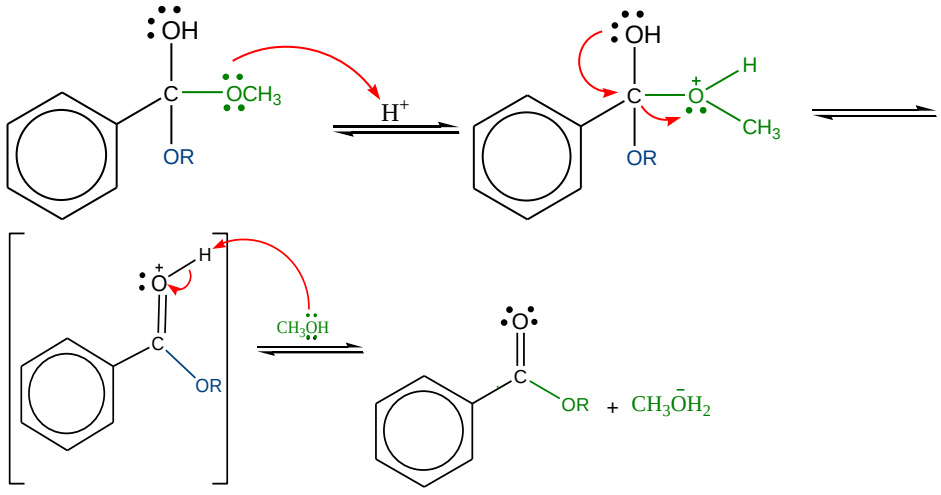
Deprotonation



Second half: Acid catalyzed elimination of leaving group

Step 1: protonation of leaving group Step 2: Elimination of leaving group Step 3:

Deprotonation



CENTRE FOR EXCELLENCE IN ENERGY AND NANO TECHNOLOGY

Academic Year 2016-2017

S.No	Name of The Project	Lab Utilization	Student Participated in the Project
1	Biodiesel From Mutton Suet	Hot plate magnetic stirrer, Glass wares, Chemical reagents	Sanjay Ragavendra S Ram Kumar S Dinesh Baabu Aravindhan R

PROJECT MEMBERS DETAIL:

PROJECT OUTCOME:

Paper Published

1. Production, Performance, Combustion, Emission Characteristics of Biodiesel synthesized from Mutton Suet. Gokul Raghavendra Srinivasan et al.10.21817/ijet/2017/v9i5/170905038, Vol 9, No 5, Oct-Nov 2017