PRODUCTION OF BIODIESEL FROM CHICKEN FAT

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ABSTRACT

The diesel engines led to emission of harmful gases such as carbon monoxides (CO), sulphur oxides (SOx) etc. due to incomplete combustion of fuel which could further led to problems like acid rains. These phenomena could also affect human health and increase global warming. Thus, with the advances in the knowledge and developing technologies, there is a way to control pollution caused by diesel engines, use of biofuel can be an alternative to current fuels. Biofuels like biodiesel is produced from variety of resources such as vegetable oils and animal fats. In this study, it could be determined that inedible animal fat could also prove a better source for production of biodiesel. In addition, few laboratory works was conducted in order to obtain important parameters that must be considered before designing, fabricating and commissioning a mini plant that could produce high purity of biodiesel.

Key words: Biodiesel, animal fat, transesterification, alkaline catalyst, KOH,

1.0 INTRODUCTION

Our society is highly dependent on petroleum for its activities. However, petroleum is a finite source and causes several environmental problems such as rising carbon dioxide, CO₂ levels in the atmosphere. About 90% is used as an energy source for transportation, heat and electricity generation, being the remaining sources used as
feedstock in the chemical industry (Carlsson, 2009). High petroleum prices and the scarcity of known petroleum reserves demand the study of other sources of energy.

Biodiesel is a non-petroleum based alternative diesel fuel that consists of alkyl esters derived from renewable feedstock such as plant oils or animal fats. The fuel is made by converting the oils and fats into what are known as fatty acid alkyl esters. The conventional processes require the oils or fats be heated and mixed with a combination of methanol and sodium hydroxide as a catalyst. The conversion process is called transesterification. (Nivedita Das, 2013).

Biodiesel production with high quality feedstock such as vegetable oil are relatively expensive compare to fossil diesel cost. Edible vegetables oil is a feedstock that commonly used in producing biodiesel. Production of biodiesel could be less expensive if the feedstock is from inedible food or waste. Therefore, one of the most promising less-expensive feedstock is animal fat such as chicken fat, beef tallow, etc. Besides to reduce the environmental problems caused by incomplete combustion of diesel engines, at the same time, by using low-cost feedstock such as inedible animal fat could indirectly reduce the waste that comes from the slaughterhouse.

Oils and fats are composed primarily of triglycerides. Triglycerides consist of a glycerin backbone with fatty acid radicals attached in place of the hydroxyls. Animal fats are readily available because slaughter industries are generally well managed for product control and handling procedure. In recent, alternatively lipid residues such as waste frying oil and inedible animal fats have also receiving considerable attention from biofuel sector. To take advantage of these low cost and low quality resources, a convenient action would be to reuse residues in order to integrate sustainable energy supply and waste management in food processing facilities.

2.0 OBJECTIVES

a) To produce a sustainable and ecofriendly fuel that could substitute the fossil fuels.

b) To prove animal fat is one of the raw materials in biodiesel production.
c) To invent a mini biodiesel plant.

3.0 MATERIALS AND METHODS

Methodology consists of four main parts which is Part 1; Laboratory works (to obtain the important parameters). Part 2; Design, Fabrication and commissioning of Mini Plant. Part 3; production of Biodiesel including the availability renewable feedstock which is Chicken Fats (CF) and the three-stage main process which is Hydrolysis, Transesterification and Washing. Part 4; the product analysis consist of conversion analysis, density analysis and combustion analysis.

3.1 Part 1: Laboratory works

The main objective of this laboratory works is to obtain important information and parameters before starting the Fabrication work. This work consist of hydrolysis of chicken fats, Acid-base titration and biodiesel synthesis and washing method.

3.2 Part 2: Fabrication of the Mini plant

This fabricated mini plant that has the capacity of producing 15 litres of Biodiesel took about 6 months of designing and fabrication work to finish. Starting by brain storming the idea on how to design a simple but efficient flow processing plant till the fabrication work to build up a new features in a whole new look, this project takes quite sometimes to finish as certain design need to be modified during the process operation. Figure 2 shows the schematic diagram of the Mini Plant which consist of main components such as Hydrolysis tank, Transesterification mixer tank, separation and washing components. The solid model of the mini plant is as shown in Figure 3.
2.3 Part 3: Process

a) Materials

The feedstock samples of Chicken Fats (CF) were provided by a local chicken supplier which has been wash thoroughly to remove foulness and bloodstain that can affect the hydrolysis process. Then, the CF is well fine-filtered to remove any unwanted part of the chicken mixed with the samples. Specific calculated amount of CF is needed to produce the desired amount of Biodiesel.

b) First step of the process is boiling up the CF along with distilled water - Hydrolysis process
The specific calculated amount of chicken fats is measured and prepared (wash and filtered) while specific amount of volume of distilled water is poured into the tank and boiled up to 100°C. Then the chicken fats is placed in a filter and put into the hydrolysis tank. The extraction of oil occurred in duration of 30 minutes and the chicken fats will produce crude oil contains a triglyceride molecule chain attached to glycerine backbone molecule chain. Ginger is mixed into the tank for odour removal process. The extraction oil from the chicken fats is then introduced to the Transesterification Process.

![Figure 3: Triglyceride Chain](image)

![Figure 4: Transesterification reaction](image)

c) Catalysed process Transesterification

The chemical reaction that converts an animal fat oil, specifically chicken fats to biodiesel is call “transesterification”. In this reaction, an ester and a alcohol (i.e. methanol) react to form a different ester. The three fatty acid chains - triglyceride (R\_1COO”) connected to the glycerol backbone are broken at their ester bond and react with the alcohol to form an alkyl esters and a glycerol molecule. Figure 4 shows the transesterification reaction.
2.4 Part 4: Analysis

a) Analysis of Biodiesel
The samples of biodiesel were analysed accordingly through respected formula below:

i. Titration Value:
Initial syringes value – Final syringes value = Titration value

ii. Free Fatty Acid value (FFA %) (KOH catalyst)
\[
\frac{\text{Titration Value}}{1.8} = \text{Approximate FFA %}
\]

iii. Amount of catalyst
Amount of catalyst = \( \frac{\text{KOH constant}}{\text{KOH Purity}} \) + Titration Value \( \times \) Volume of CFO process
- KOH constant: 7 g/litre
- KOH purity: 95%,
- Volume of CFO process: 10 litres

iv. Conversion Analysis
Conversion Efficiency = \( \frac{\text{Volume of biodiesel produced, liters}}{\text{Volume of oil use, liters}} \) \times 100 %

v. Density Analysis
Density, g/ml = \( \frac{\text{Mass of sample, g}}{\text{Volume of sample, ml}} \)

vi. Combustion Analysis
The product Biodiesel (alkyl ester) is combust in alternative fuelled engine to observe the combustion and the exhaust gas.
3.0 RESULT AND DISCUSSION

3.1 Hydrolysis Of Animal Fat

Table 1: Conversion analysis of extracted chicken oil

<table>
<thead>
<tr>
<th>BEAKER</th>
<th>CHICKEN FATS (g)</th>
<th>DISTILLED WATER (ml)</th>
<th>OIL EXTRACTED (ml)</th>
<th>TIME TAKEN (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEAKER A</td>
<td>100</td>
<td>300</td>
<td>80</td>
<td>30</td>
</tr>
<tr>
<td>(non-cut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEAKER B</td>
<td>100</td>
<td>300</td>
<td>80</td>
<td>30</td>
</tr>
<tr>
<td>(cut)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From this experiment, the scale of oil can be extracted from chicken fats is known. Error might come from human error, technical error. Human error could be listed as eyes were not perpendicular to the measuring scale of the apparatus used, neglected time counting, non-written data and etc. Technical error may be from heating element and apparatus failure.
3.2 Titration of Oil to Make Biodiesel (Acid-Base Titration)

Table 2: Result for titration solution added to neutralize the free fatty acid

<table>
<thead>
<tr>
<th>Beaker</th>
<th>Titration solution added (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1 ml</td>
</tr>
<tr>
<td>B</td>
<td>1 ml</td>
</tr>
<tr>
<td>C</td>
<td>1 ml</td>
</tr>
<tr>
<td>Average</td>
<td>1 ml</td>
</tr>
</tbody>
</table>

1 ml NaOH/KOH = 1 acid value

a) Titration Calculation

Table 3: Required catalyst for different type of caustic soda

<table>
<thead>
<tr>
<th>Caustic Soda</th>
<th>Catalyst purity (%)</th>
<th>Base (g/l)</th>
<th>Required Catalyst (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium Hydroxide(KOH)</td>
<td>80 @ 0.8</td>
<td>8.75</td>
<td>9.75</td>
</tr>
<tr>
<td>Sodium Hydroxide(NaOH)</td>
<td>90 @ 0.9</td>
<td>6.1</td>
<td>7.1</td>
</tr>
</tbody>
</table>

b) Base Calculation

- Base (KOH) = \(\frac{7 \text{ (g/l)}}{\text{catalyst purity}}\)
  \[
  \frac{7 \text{ (g/l)}}{0.8} = 8.75 \text{ g/l}
  \]

- Base (NaOH) = \(\frac{5.5 \text{ (g/l)}}{\text{catalyst purity}}\)
  \[
  \frac{5.5 \text{ (g/l)}}{0.9} = 6.1 \text{ g/l}
  \]

c) Required Catalyst

- Required catalyst (g/l) = Base + Titration Solution Added
For KOH: $8.75 \text{ (g/l)} + 1 = 9.75 \text{ grams per litre of oil (g/l)}$

Therefore, if 100 ml of oil used, $100 \text{ ml} = 0.1 \text{ litre}$

\[9.75 \text{ (g/l)} \times 0.1 \text{ (l)} = 0.975 \text{ gram of KOH needed}\]

For NaOH: $6.1 \text{ (g/l)} + 1 = 7.1 \text{ grams per litre of oil (g/l)}$

Therefore, if 100 ml of oil used, $100 \text{ ml} = 0.1 \text{ litre}$

\[7.1 \text{ (g/l)} \times 0.1 \text{ (l)} = 0.781 \text{ grams of NaOH needed}\]

### 3.3 Free fatty Acid Conversion Factor

- **For KOH Titration Solution:**
  \[
  \frac{\text{Titrated solution added (ml)}}{1.8} = \text{Approximate FFA %}
  \]
  \[
  \frac{1}{1.8} = 0.6 \%
  \]

- **For NaOH Titration Solution:**
  \[
  \frac{\text{Titrated solution added (ml)}}{1.3} = \text{Approximate FFA %}
  \]
  \[
  \frac{1}{1.3} = 0.8 \%
  \]

In this experiment, acid-base titration was conducted to identify the amount of caustic soda (lye) that is required for the Transesterification Process in further experiment. Firstly, apparatus were prepared and safety precaution must be taken in order to prevent any accidents. Safety gloves, mask and lab coat must be worn.

Titration method must be done properly in order to reduce errors as well as to get an accurate result. Besides, three attempts were conducted and data was recorded. At first, alcohols such as isopropyl must be poured to a beaker in order not to contaminant the isopropyl alcohols. Caustic sodas such as NaOH and KOH must be covered from the surrounding to prevent melting which could spoiled the caustic soda. Syringes that has been used must be washed and dried to prevent contamination of sample as well as the alcohols.
Hence, oil sample must be heated up to 70°C in order to reduce the viscosity of the sample. Besides, while titrating the oil, it was important to observe promptly the changes of solution from colorless to pinkish color.

3.4 Plant efficiency

The yielding quantity of 2 batches of hydrolysis process equivalent to 20-litres of the raw oil plus the reactants resulted in generating 18-liters of biodiesel which equivalent to 95% efficiency of production. Time consumed is approximately 40 minutes to produce crude biodiesel. 5% of glycerol produced could be used for other purpose.

4.0 CONCLUSION

In conclusion, chicken fat could be one of the low cost feedstock as well as to produce a sustainable and ecofriendly fuel that could substitute the fossil fuels. Result for density and combustion are not stated due to some technical problem at this time.

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