

Production of Biodiesel from Biowastes

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ABSTRACT: Waste management is considered to be as the serious issue in our society, especially the waste coming from the slaughter houses. Disposal of these wastes is also another problem. Slaughter waste can be effectively used as a raw material to produce the biodiesel by extracting the fats present in it. By rendering process, fats can be extracted and by-product can be used as feed for the pets and fishes and can use as bio-fertilizer. After extracting the fats from these wastes, it should be converted into oil, which does not have the commercial value at present. By-product obtained will be high protein meat and bone meal. Good quality biodiesel can be produced from the rendered oil followed by a two-step reaction which includes acid catalysed etherification of Free Fatty Acids (FFA) and base catalysed transesterification of triglycerides and the by product will be glycerol. The use of heterogeneous catalyst (CaO) increases the biodiesel yield and can be easily separate from the biodiesel. The aim of this study is to produce the biodiesel from the slaughter waste. For an optimum methanol molar ratio, reaction time, reaction temperature and catalyst concentration about 93.1% of yield obtained from the reaction.

KEYWORDS: Slaughter waste, Heterogeneous catalyst, Transester-ification, Biodiesel etc

I. INTRODUCTION

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. Among the feedstock, most of the raw materials derived from fossil fuels. Slaughter waste has become a major source of pollution throughout the world. The disposal of this waste is a daunting task. Disposing these waste at uninhabited areas will leading to ground and surface water pollution, and results in major health hazards posed by indiscriminate breeding of microorganism, parasites, house flies and stray dogs, which finally affect the environment. Slaughter waste of chicken, pig, beef, and mutton can be used as a raw material for the production of biodiesel, mainly by extracting the fat present in their slaughter waste. The fats present in slaughter waste can extracted by rendering process. Rendering is an excellent way to recycle a troublesome waste material into a good feed ingredient. Using low-cost feedstock such as rendered animal fats in biodiesel production will cause biodiesel expenditures to be reduced. Moreover, it has also been reported that the chemical and physical properties of biodiesel are better than those of the fossil-derived diesels such as higher lubricating quality and lower sulfur content. Biodiesel is comprised of fatty acid alkyl esters, which can be typically synthesized from vegetable oils or animal fat via chemical reaction called transesterification.

A. REVIEW: BIODIESEL FROM SLAUGHTER WASTE

Biodiesel from animal fats, compared with biodiesel from vegetable origin has the advantage a higher cetane number, the most significant indicator of diesel combustion behaviour. Nevertheless, the fuel produced from fats has higher cold filter plugging point because of this, raw material has higher content of saturated fatty acids. Furthermore biodiesel from animal fats is less stable for oxidation, this fact being attributed to the absence of natural antioxidants as compared to biodiesel of vegetable origin. For these properties, the biodiesel produced from animal fats might not be adequate to use it 100% pure in vehicles during cold weather; however might be used 100% pure in boilers for heat generation.

Alternatively, fats might be mixed with other raw materials to get a biodiesel obeying such quality specifications, being even possible to enhance some biodiesel properties by incorporation of fats in the raw material.

Biodiesel can be effectively used as an alternate fuel. Most probably biodiesel are produced from edible oils, mainly vegetable oils. While producing biodiesel from these edible vegetable oils, the production cost as well as the cost of biodiesel will be 3 to 4 times more than commercial diesel produced from non-renewable sources. Raw material such as inedible fats of animals, poultry fats, waste cooking oil, and inedible vegetable oils can be effectively used as low cost raw material for the production of biodiesel. Inedible animal fats and poultry fats are major sources of waste from the slaughter houses, and also waste cooking oil from the restaurant, excessive use of this used oil in food will result in certain health problem and finally results in cancer. By using these raw materials, waste coming from the slaughter houses can be reduced and also avoid the excess use of used cooking oil. So these inexpensive and cheap raw materials can be used as an excellent low cost feedstock for producing biodiesel.

B. HETEROGENEOUS CATALYST SELECTION

Different types of catalysts are used for the production of biodiesel through transesterification reaction. It mainly includes homogeneous catalysts, heterogeneous catalysts and some enzymes. transesterification reaction rate is relatively fast by using homogeneous catalysts (e.g. NaOH and KOH), there are some difficulties associated with the use of homogeneous catalyst for biodiesel production, for example, it has high corrosive nature, it is hard to be separated from the product, it is unable to be reused, and huge amount of wastewater is generated during transesterification reaction. Heterogeneous catalysts have the advantages over the homogeneous catalysts, such as, it is easy to handle, separate from the biodiesel product and reuse, which can significantly lower the biodiesel production cost. Among several types of heterogeneous catalysts, CaO-based catalysts have gained more attention as the heterogeneous basic catalysts for biodiesel production because of its non-toxicity, high basic properties and low solubility in biodiesel. Moreover, the discovery of inexpensive and efficient. CaO catalysts from natural waste materials such as duck eggshell, oyster shell, scallop shell, mussel shell, wood ash, snail shell and chicken bones makes the process for producing biodiesel even more cost-effective[7].

II. RELATED WORK

1. Huapping et al. (2006) achieved vegetable oil conversions up to 93 wt% using thermally treated calcium oxide at 700 °C, 2.5 h, 1.5% CaO and 9:1 molar ratio of methanol to oil and reaction temperature of 60 C.
2. Lopez et al. (2007) found that 94% FAME yield was obtained for 3% CaO, 13:1 methanol molar ratio, 100 min of reaction time, 60 °C reaction temperature from sunflower oil.
3. Kawashima et al. (2009) studied the catalytic activity of calcium oxide for the trans-esterification of rapeseed oil with methanol. He stated that by pretreating CaO with methanol, a small amount of CaO was converted into Ca (OCH₃)₂, which acted as the initiating reagent for trans-esterification. Subsequently, the calcium-glycerol complex formed in the reaction of CaO with glycerol functioned as the main catalyst in trans-esterification.
4. Veljkovick et al. (2009) found that 98% of FAME obtained for 1% of CaO, 6:1 methanol molar ratio, 2hrs reaction time and 60 °C reaction temperature from sunflower oil. CaO was calcined at a temperature of 550⁰ C.
5. Yoosuk et al. (2010) found that 93% of FAME was obtained for 7% of CaO, 15:1 methanol molar ratio, 1hrs of reaction time and 60⁰ C reaction temperature from palm oil. CaO was obtained from CaCO₃ and calcined at 8000C for 3 hrs.
6. Kouzu et al. (2010) achieved vegetable oil conversions using calcium oxide after 1 h of reaction, at 65 °C, using a 12:1 molar ratio of methanol to fat and 8% CaO and FAME yield was 93%.
7. Thawatchai et al. (2016) achieved 90% of FAME yield for 7.5% of CaO obtained from chicken manure, 15:1 methanol molar ratio, 6hrs of reaction time and 65⁰C reaction temperature. Cao was calcined at 850⁰ C for 2.5hrs. The reaction procedure at the optimum reaction condition was described as follows: 15 g of waste cooking oil was first

mixed with 1.13 g of the CaO catalyst at a reaction temperature of 65⁰C with continuous stirring at a stirring speed of 1400 rpm until the reaction mixture was uniform. After that, 7.3 g of the dehydrated methanol was added into the obtained reaction mixture and the trans-esterification reaction was then carried on.

III. MATERIALS AND METHODS

A. RAW MATERIALS

Raw materials are mainly the slaughter waste of general meats (Chicken,pig,beef etc.).It was collected from the bramagiri slaughter house in Manathavady.

B. RENDERING OF SLAUGHTER WASTE

Waste fat from slaughter waste carcasses are removed and then made into an oil using a rendering process. Rendering consists of grinding the slaughter waste by-products to a fine consistency and cooking them until the liquid fat separates and pathogens are destroyed. The solids are usually passed through a screw press to complete the removal of the fat from the solid residue. The cooking process also removes water, which makes the fat and solid material stable against rancidity. The end products are fat, and a high-protein feed additive known as meat and bone meal. After this process the rendered oil is obtained with is used for transesterification reaction.

C. CATALYST PREPARATION

CaO was used as the catalyst for transesterification reaction. First of all, CaO was pre-treated with the methanol to form calcium methoxide, which acted as the initiating reagent for transesterification. Subsequently, the calcium-glycerol com-plex formed in the reaction of CaO with glycerol functioned as the main catalyst in transesterification[3].

D. ACID CATALYST ESTERIFICATION

The presence of free fatty acids in oils causes significant processing problems in standard biodiesel manufacturing, since the free fatty acid is readily saponified by the het-erogeneous alkali catalyst used to transesterify triglycerides, leading to a loss of catalyst as well as increased purification costs. Free fatty acids (FFA) react with the basic catalyst added for the reaction and give rise to soap, as a result of which some portion of the catalyst is neutralized and is therefore no longer available for transesterification. The main approach for improve the processing of free fatty acid oils is to first esterify the free fatty acids to alkyl esters in the presence of an acidic catalyst before transesterification. The pretreated oils, in which the free fatty acid content is lowered to less than 1wt%, can then be processed under standard transesterification (figure 1) reaction conditions[8].

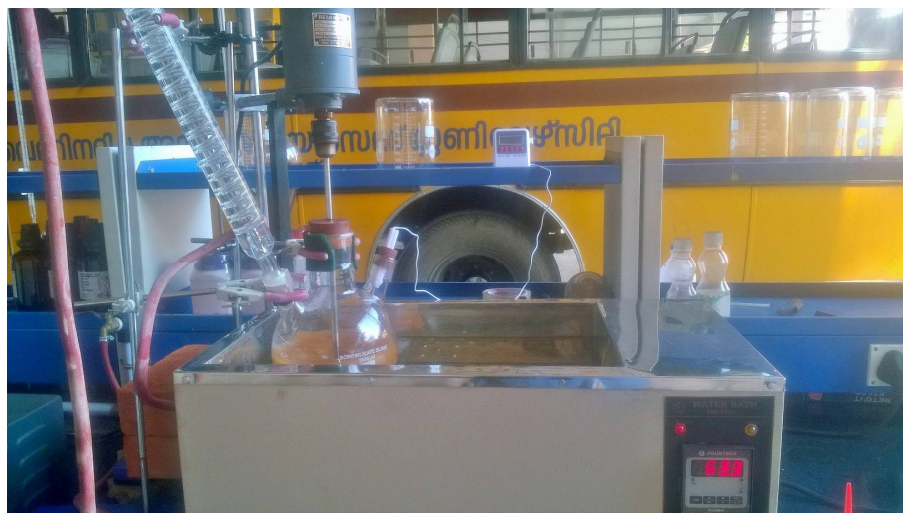


Figure 1: Apparatus for Acid catalyst esterification

E. BASE CATALYST TRANSESTERIFICATION

The transesterification reaction involves catalytic reaction between triglyceride and alcohol (e.g, methanol, ethanol, propanol and butanol) to form biodiesel (FAMES) and glycerol. In the reaction, three consecutive reactions are required to complete the transesterification of a triglyceride molecule. In the presence of base catalyst, a triglyceride molecule reacts with an alcohol molecule to produce a diglyceride and FAME(Fatty acid methyl ester). Then, a diglyceride reacts with alcohol to form a monoglyceride and FAME. Finally, an monoglyceride reacts with alcohol to form FAME and glycerol. Diglyceride and monoglyceride are the intermediates in this process[6].

F. EXPERIMENTAL SETUP FOR TRANSESTERIFICATION

A laboratory scale biodiesel reactor was setup, see figure 2. It mainly consist of three necked 2000ml round bottom flask. A reflux condenser, thermometer and mechanical stirrer was attached to the round bottom flask. The temperature of the oil inside the flask was digitally controlled by the water bath. The reflux condenser is provided in order to recover the methanol that evaporates during the reaction. After the trans-esterification reaction a separating funnel was used for separating the biodiesel and glycerol.



Figure 2: Experimental setup for transesterification

G. Experimental condition for transesterification

Methanol Ratio	CaO %	Reaction Temp (^o C)	Reaction Time
12:1	3%	60 ^o C	2hr
6:1	1.5%	60 ^o C	1.5hr
3:1	0.5%	60 ^o C	1hr

The reaction will be carried out 3 times for each variation i.e. yield of FAME for different methanol molar ratio, yield of FAME for different catalyst concentration, yield of FAME for different reaction time. The optimum concentration of methanol molar ratio, catalyst concentration, reaction time for maximum FAME yield will be worked out.

IV. RESULTS AND DISCUSSION

A. DRY RENDERING PROCESS

Slaughter waste carcass were broken down with a pre-breaker followed by cooking at 1000C for 20 min, sterilize at 120-1400C at 1-3 kg/cm² and drying at 1000C for 1 hour in cooker. After unloading from the cooker, it undergoes centrifugation at 1000 rpm for 20 min. Rendered oil will obtained from the dried carcass due to centrifugation. The by

product will be a high protein meat and bone meal. It will cooled down and pulverised in a hammer mill and used as a pets meal.

B. STEP:1 ACID CATALYST ESTERIFICATION

FFA content of fat sample was determined according to the AOAC method (AOAC 2000). The FFA was found to be 22.91%. So FFA should be reduced to less than 1%. Acid catalysed esterification of FFA with 30:1 methanol molar ratio, 10% H₂SO₄ concentration at 60^oC for a reaction period for 120 minutes, could significantly reduce the FFA value of rendered oil to a minimum value of 0.705% [9].

C. STEP:2 BASE CATALYST TRANSESTERIFICATION

In order to obtain the optimum value of conversion of rendered oil to biodiesel, the reaction were carried out 3 times for each variation, finding out and standardizing the values which gave the maximum yield of biodiesel. i.e methanol molar ratio varied from 3:1, 6:1 and 12:1. CaO concentration was varied from 0.5% to 3%. Reaction temperature was set at 60^oC in order to avoid the excess evaporation of methanol. Reaction time was varied from 1hr, 1.5hr and 2 hr.

For an optimum methanol molar ratio 6:1, CaO catalyst 1.5% to triglycerides at 60^oC for 60 minutes reaction period produced the maximum biodiesel yield of 93.1%.

D. BEST RESULTS OF EXPERIMENTS DURING TRANSESTERIFICATION

METHANOL RATIO	CaO (%)	REACTION TEMP(^o C)	REACTION TIME	YIELD(%)
12:1	0.5	60 ^o C	2HR	93.3
12:1	1.5	60 ^o C	1.5HR	91.7
12:1	0.5	60 ^o C	1.5HR	89.4
12:1	1.5	60 ^o C	1HR	91.7
6:1	0.5	60 ^o C	1.5HR	86.1
6:1	1.5	60 ^o C	2HR	87.3
6:1	1.5	60 ^o C	1HR	93.1
6:1	0.5	60 ^o C	1HR	88.3
3:1	0.5	60 ^o C	1.5HR	81.5

E. EFFECT OF HETEROGENEOUS CATALYST (CAO)

Homogeneous basic catalysts such as KOH or NaOH can provide high FAME yield under mild conditions. A safe and practical application of FAMES as diesel fuel requires a purification process by removing the impurities of the catalyst using a water-washing procedure; however, this procedure is complicated, expensive, and requires a large amount of water disposal[10]. In order to reduce the costs of this procedure and to minimize the wastewater, it is possible to use a heterogeneous solid catalyst. This type of catalyst has the advantage of easy separation from the biodiesel phase and, as a result, the amount of wastewater can be decreased. Calcium oxide (CaO) is one of the most promising heterogeneous catalysts for biodiesel production due to its excellent catalytic properties, low solubility in biodiesel and methanol, simple production process, and low cost. Moreover, calcium oxide is noncorrosive and can be prepared from waste materials consisting of calcium carbonate (CaCO₃). The use of waste materials is not only effective in enhancing the cost advantage of CaO catalyst, but also related to the ability to recycle the natural mineral resources which makes the process environmentally friendly[2].

F. RENDERED OIL AND MEAT AND BONE MEAL YIELD

About 300 kg of waste was collected from the slaughter house. After the rendering process about 27 kg of rendered oil was obtained, approximately 9% of oil from the waste. About 30-35% of the slaughter waste given into the cooker can be converted into meat and bone meal, which can be used as a pet meal.

F. BIODIESEL YIELD

From 27 kg of rendered oil 90 % of the biodiesel can be obtained, which is about 24 kg of pure biodiesel.

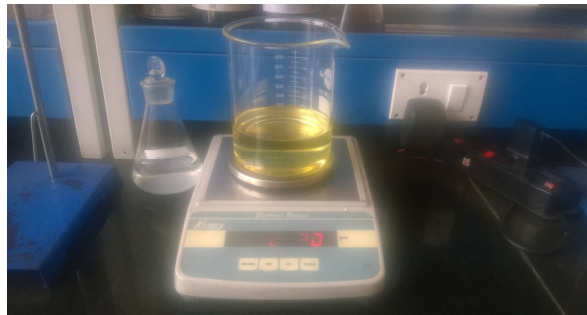


Figure 3: Biodiesel yield from the system

V. CONCLUSION

Slaughter waste is considered a promising cheap alternative feedstock for biodiesel production that does not compete with edible vegetable oil. Although the transesterification reaction rate is relatively fast by using homogeneous catalysts (NaOH, KOH), the catalyst cannot be recovered and must be neutralized at the end of the reaction. The use of heterogeneous catalyst (CaO) will be easy to handle, separate from the biodiesel product and reuse, which can significantly lower the biodiesel production cost. CaO has minor toxicity and high availability possesses relatively high basic strength and less environmental impacts due to its low solubility in methanol and its easier handling as compared to KOH/NaOH. Low cost CaO can be obtained from egg shells, duck shells; oyster shells etc. will further reduce the production cost of biodiesel. High FFA in the rendered oil can be reduced by a two-step reaction i.e acid esterification and base transesterification. Methanol molar ratio of 6:1, 1.5% of CaO concentration and 1hr of reaction time, about 93.1% of yield obtained for a reaction temperature of 60°C. Slaughter waste as a raw material for production of biodiesel not only offers the environmentally friendly and cost-effective way to recycle those wastes (minimizing many problems those are related to the disposal of those wastes), but also help to lower the biodiesel production cost.

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