PRODUCTION OF ALTERNATE FUEL (BIO DIESEL) FROM WASTE COOKING OIL

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ABSTRACT

Waste cooking oil, mainly coming from frying residues, can be used as raw materials to obtain a diesel fuel (bio diesel). As such feedstock materials can be replenished readily; bio fuel is considered as a renewable energy resources. Biodiesel a nontoxic, biodegradable, diesel-like fuel, is an important energy alternative capable of decreasing the environmental problem caused by consumption of fossil fuels. The utilization of waste vegetable oil or reused cooking oil as raw material in bio diesel production was studied. Research was undertaken establish the availability of reused cooking oil to supply a bio diesel process. It is intended that this work from an academic study combined with an environmental and technological analysis of the merits of bio diesel as a sustainable fuel. Laboratory experimentation will be investigate the possibility of using waste cooking oil from the local fast food chain, and potassium hydroxide as catalyst for the transesterification process. The cleaned waste cooking oil undergoes transesterification for four hours, after which, the bio diesel is separated from glycerin by gravity. Washing is necessary to remove residual catalyst or soap.

Key words: Waste cooking oil, Sulpuric acid, Mussel shell powder, Methanol, Tranesterfication process

INTRODUCTION

Since the advent of the industrial revolution, the daily energy usage has risen alarmingly, which is a direct result of advances in our lifestyle as well as technology and transportation used.

Most of these advancements have come through the use of fossilized fuel sources, and this has caused a two-fold problem: the steady rise in environmental pollution combined with the sharp rise in oil prices because demand is higher than ever while supply chains are on the brink of collapse due to dwindling fuel reserves [1]. Biodiesel has gained much attention as an environmentally friendly alternative to petroleum-based diesel [2]. Biodiesel has been shown to possess very desirable qualities. It is renewable, nontoxic, biodegradable, has inherent lubricity, contains little or no sulfur giving it good emission characteristics and it can be used in already existing engines without the need for significant modifications [3]. Its good miscibility with petro diesel means that it can be blended in different proportions with petro diesel. Besides, the need for more energy supply due to the increased energy consumption, have only left us to face an energy crisis [4]. The current consumption of worldwide petroleum product saves and expanding discharge of ozone depleting substances prompting worldwide warming, dissolving of the polar icecaps and an ascent in ocean levels are of major worldwide concern [5-6]. Henceforth, the expanding calls for elective wellsprings of fuel with low emissions of ozone harming substances makes bio fuels an extremely appealing choice.

The microalgae have an immense potential of accumulating lipid at an efficient rate, that can be transesterifies into biodiesel [5,8,9]. Also, microalgae are capable of being cultivated in both fresh and marine waters, which make up 66% of the world's surface. In this manner, micro algal biomass can fill in as an extraordinary source to meet present and future fuel requests [7]. However, the utilization of all the water resources for algae cultivation to recover bio fuel producing lipids may deprive. the nutrients available for other fresh and marine water plants and animals. Apart from this excess growth of algae irrespective of its utility may lead to undesirable discoloration, scum formation, odors and toxic effects. Biofuels, produced from biomass, offer new chances to: (i) expand the flexibly sources; (ii) grow long haul substitution for non-renewable energy sources; lessen the emanation of ozone harming substances; and (iii) support the decarburization of transportation fuels.

Biodiesel and bioethanol are promising alternate fuels that have equivalent performance and combustion characteristics, and reduced emissions when compared with conventional diesel and petrol. Biodiesel is delivered from the transesterification of oil for the most part acquired from oil rich yields for example, rapeseeds, palm, and sunflower and produce low ozone harming

substances. Alternatively, solid-base catalysts such as carbon oxide bring about heterogeneous and highly efficient transesterification reaction. When compared to homogeneous acid catalysts, a homogeneous base catalyst have faster reaction rates, catalyzes reaction at low temperatures and pressures, less corrosive and are readily available [11]. Also, heterogeneous catalysts allow simultaneous esterification and transesterification. Reactions to occur, eliminate the extra washing step for biodiesel purity, and can be hydrophobic and are tolerant to presence of water in feedstock. That is, they allow for reduced cost of biodiesel production. In the context of the current work, the focus is on waste cooking oil (WCO). It is obtained from edible oils that have been used for frying food. In Nigeria, a large volume of WCO is generated annually from the major restaurants, hotels, catering services and household kitchens [12]. The conventionally used homogeneous liquid catalysts are not suitable for oils with high free fatty acid content because of the production of soap which reduces biodiesel yield [13]. The homogeneous catalysts cannot be recovered and the need for extra purification and product separation steps results in the generation of biodiesel wash water which needs to be properly managed. Heterogeneous catalysts have begun to receive significant attention as better alternatives because they are thermally stable, nontoxic, noncorrosive, environmentally friendly and reusable. Producing heterogeneous catalysts from waste materials could potentially reduce the cost associated with biodiesel production. Some materials that have been used as precursors for heterogeneous catalysts include waste chicken bones, oyster shell, obtuse horn shell eggshell and conch shell. Combined waste chicken and fish bones to produce a composite heterogeneous catalyst and obtained a biodiesel yield of 89% with used cooking oil. [14] Produced a mixed metal oxide catalyst from anthill and eggshell and doped the mixture with nickel and cobalt to improve functionality.[16]produced a composite clay-eggshell catalyst and reported a maximum biodiesel yield of 65.2%.

For an optimum biodiesel production process, the amount of methanole, catalyst dosage, reaction temperature and reaction time are the major process factors to consider for optimization [16], which is based on statistically designed experiments has been used by many researchers. It is better than the traditional one-factor-at-a-time optimization method as it utilizes a reduced number of experiments, can elucidate the interaction between variables and can help to identify the true optimum conditions. In this study, the aim is to advance research for a more economical process for the production of biodiesel from waste cooking oil by developing a heterogeneous

catalyst from waste sea mussels.. The combination of sea mussels to produce a heterogeneous catalyst for biodiesel production has not been reported previously and this forms the thrust of this work by exploring a novel, cheap and environmentally benign catalyst for biodiesel production.

FLOW CHART

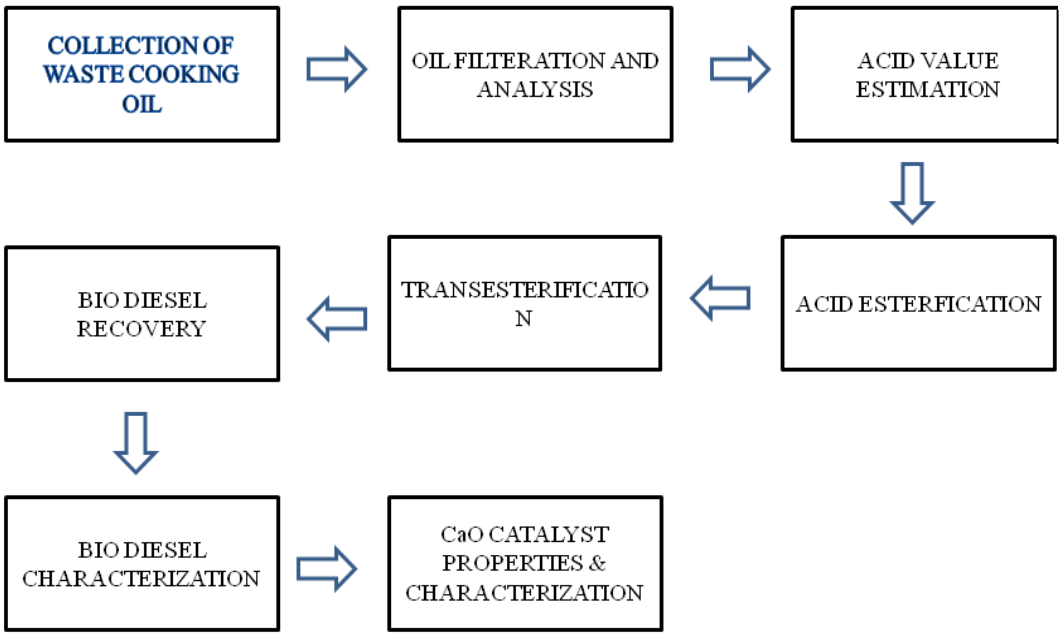

Figure 1. Flow Chart for Research and Methodology

MATERIALS AND METROLOGY

The waste cooking oil used in this study was procured from home based coconut cooking oil. The collected WCO contained some food particles and water and was first filtered with WHATMAN filter paper and then heated at 120 ◦C to reduce the moisture content [17]. Sea Mussel shells used as precursor material for catalyst production was obtained from a local market in Thengapatnam beach, kaniyakumari. The other reagents used in the study were of analytical grade and were provided by the Chemical Engineering Laboratory at the ST.XAVIER'S CATHOLIC COLLEGE OF ENGINEERING, Kanyakumari.

Catalyst Preparation

The mussel shells were first thoroughly washed with hot water to aid the removal of proteins and lipids and then with tap water and sun-dried for 4 d. The shells were milled to powder form using a special purpose milling machine and then sieved to obtain 300 μm particles. The powdered crab shells were calcined at a temperature of 900°C for 4 h in a muffle furnace and then allowed to cool overnight before being placed in desiccators to prevent contamination and subsequently stored in an airtight container. Extraction setup in purified cooking oil mixed with 5g of catalyst powder heated by muffle furnace.

Catalyst Characterization

To assess the properties of the synthesized catalyst and the precursors (mussel shell and waste cooking oil), the samples were subjected to various characterization tests. The surface structure and elemental composition of the samples were analyzed using scanning electron microscopy coupled with energy dispersive X-ray (SEM-EDX). The composition of oxides was determined through X-ray fluorescence (XRF) analysis. The surface area and pore properties were determined using the Brunauer, Emmett and Teller (BET) and Barrett-Joyner-Halenda (BJH) analyses. The crystalline phases were elucidated using X-ray diffraction (XRD) analysis. Studies of the bond structure and interactions were carried out via Fourier transform infrared (FTIR) spectroscopy analysis where all infrared spectra from the different samples were read from 4000 to 400 cm− 1 with the Pelkin Elmer 3000MX spectrometer. The thermal stability of the catalyst was assessed using thermogravi metric analysis (TGA).

Biodiesel Production and Characterization

A one-step transesterification process was employed for biodiesel production based on the bifunctionality of the heterogeneous catalyst and the low acid value of the oil (4.7 mg KOH/g oil; FFA = 2.38%). A measured amount of the WCO was dispensed in a three-necked 250 ml glass reactor incorporating a reflux condenser. The setup was placed on a hot plate magnetic stirrer and heated to a set temperature. Methanol was added to the oil and mixing was allowed to occur for 5 min, after which the catalyst was added for the reaction to occur for a predetermined duration. The reaction temperature, methanol to oil molar ratio, amount of catalyst and reaction

time were all fixed according to the experimental design [18]. At the end of the reaction, a filter cloth was used to separate the catalyst from the liquid which was then transferred into a separating funnel and allowed to settle overnight. The bottom layer containing glycerol was tapped off, while the upper layer containing biodiesel and some unreacted methanol was heated in an oven to evaporate the methanol. The resulting biodiesel was then stored in preparation for further analysis. The yield of biodiesel produced was calculated from Equation (1). Some physicchemical (density, viscosity, moisture content, acid value) and fuel properties (flash point, cetane number and calorific value) of the biodiesel produced were determined following standard methods (Association of Official Analytical Chemists (AOAC), 1990). Gas chromatography-mass spectroscopy (GC-MS) analysis was used to determine the fatty acid composition of the biodiesel.

$$\text{Biodiesel yield} = \frac{\text{mass of biodiesel produced}}{\text{mass of WCO used}} \times 100$$

Catalyst Reusability Studies

The reusability of the catalyst was assessed by using it to catalyze successive transesterification reactions under the optimized conditions. For each run, the catalyst was recovered from the biodiesel mixture via filtration and then washed with hexane before oven-drying at 80 ◦C for 12 h. The recovered catalyst was then used to catalyze the reaction for six cycles.

Figure 2. Mussel Shell Powder

RESULT AND DISCUSSION

Physical and chemical pro perties of fuel are important in determining its quality. Biodiesel is purchased from local distributor Bio motor Prod. Biodiesel is produced from waste cooking oil of canola and soybean cooking oils. Physical and chemical properties are measured according to local standards with the help of supplier and Faculty of Chemistry. A comparison of European biodiesel standard and properties of biodiesel obtained from waste cooking oil is given in table 1.

Table 1. Physical chemical properties of biodiesel from waste cooking oil, diesel fuel and biodiesel standard EN 14214

Properties	Test Method	Biodiesel from waste cooking oil	EN-14214
Density(kg/m3) @ 25°C	SR EN ISO 3657	887.6	860-900
Kinematic viscosity(cSt) @ 40°C	ASTM D-445	4.5	3.5-5
Flash point (°C)	EN SR ISO 5489: 2009	159	>101
Saponification value (mgKOH/g)	SR EN ISO 3657: 2005	189	
Acid value (mgKOH/g)		0.32	
Iodine value (mgIod/g)		94	<120

Table 2. Production of bio diesel using methanol and sulphuric acid by using 20% mussel shell powder (catalyst)

RATIO	Bio diesel	Waste cooking oil
0% (methanol, sulphuric acid)	0	100
10%(methanol, sulphuric acid)	18.5	81.5
25%(methanol, sulphuric acid)	39.6	60.4
50%(metanol, sulphuric acid)	63.86	36.14

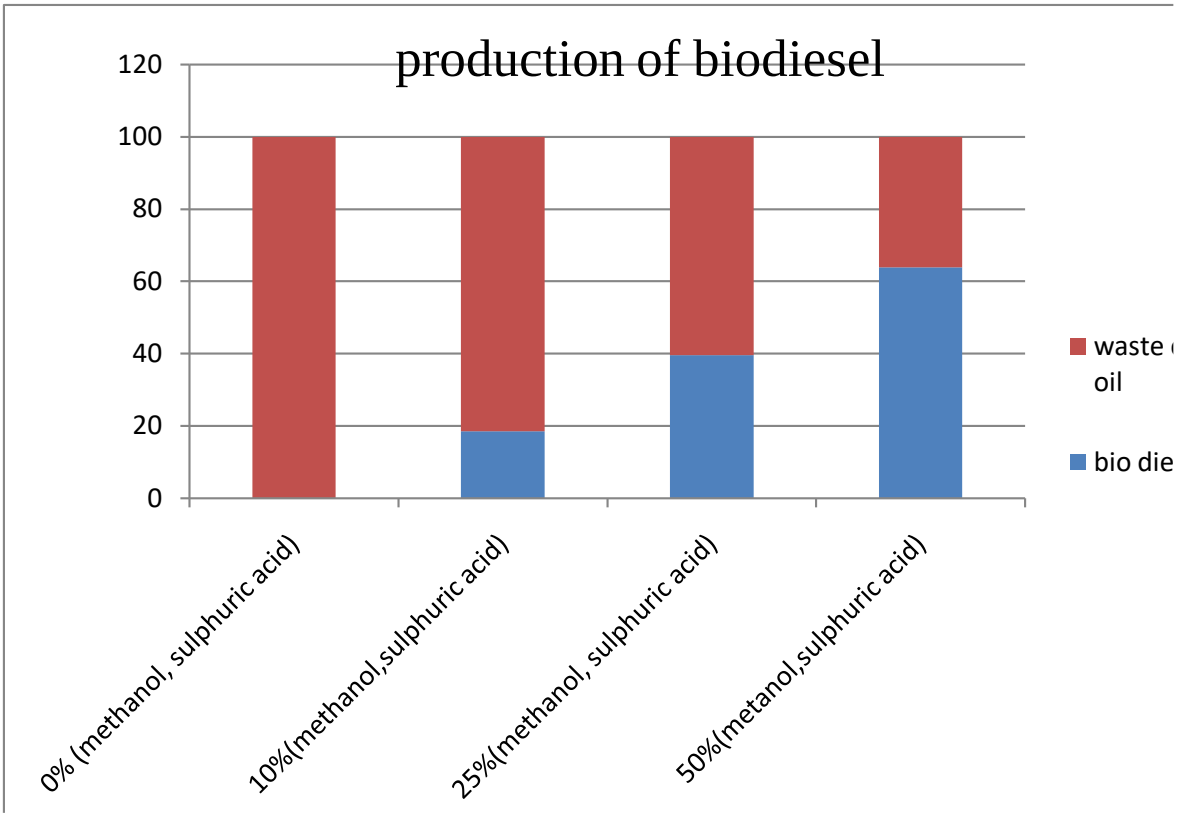

Figure 3. Production of Biodiesel

Biodiesel production from waste cooking oil ensures supply of sustainable and renewable fuel. Water content, alcohol type, alcohol to oil ratio, catalyst type and concentration, free fatty acids, reaction time, pH, stirrer speed and temperature are the parameters which have great impact on transesterification process. Comparative analysis of physical and chemical properties was carried out which concluded that the properties of biodiesel obtained from waste cooking oil lie within the limits of European biodiesel standard EN 14214. Emission performance of diesel engine for diesel-biodiesel blends have shown following results. Increase in CO2 emissions is recorded with increasing load but decrease in emissions is recorded with increase in concentration of biodiesel in blends. Hydrocarbon emissions are recorded lower for higher loads and higher biodiesel concentrations of biodiesel in blends. Carbon monoxide emissions were lower for higher loads while decreases in CO emissions are recorded with higher concentration of biodiesel in blends. Biodiesel produced from waste cooking oil has economic and environmental benefits over conventional fuels. Romania has existing infrastructure for production and usage of biodiesel from waste cooking oil. Furthermore, it can be concluded that

energy share of biodiesel in fuel market helps in achieving EU emission targets as well as to fulfill Kyoto protocol limitations.

Biodiesel has attracted extensive attention in the world as it is a renewable, biodegradable, nontoxic and environmentally friendly new alternative transportation fuel. It can be made from different feedstock containing fatty acids such as animal fats, no edible oils, waste cooking oils, by products of the refining vegetables oils and algae etc. Transesterification process is a commonly employed for its formation. Heterogeneous catalysts are recommended the best catalysts in biodiesel production. Cost of biodiesel can be reduced by using waste cooking oil as feed stock. High fatty acid content in waste cooking oil can be reduced by pre-treating waste cooking oil with acid catalyst. Water produced during the etherification process may inhibit acid catalyst. It can be removed by stepwise reaction mechanism. Methanol is the most suitable alcohol because of its low cost and easy separation from biofuel. But still there is need to improve the biodiesel process economically using environmentally friendly catalysts and selecting the best process technology.

CONCLUSION

The use of edible oils being in direct conflict with human consumption interests, rubber seed oil is one of the more sustainable inedible feedstock for biodiesel production since rubber plantations are widespread, making rubber seed sourcing for oil production cost effective. The very low FFA content additionally makes it easily convertible in a single acid or base catalyzed stage without saponification issues. This forms the basis for the presented study where biodiesel synthesis from rubber seed oil has been reported using two catalysts: CaO derived from calcined waste MUSSEL SHELL and Zn-CaO prepared by doping (wet impregnation) ZnNO3 on to the CaO support obtained from the calcination of MUSSEL-SHELL. For optimization of the synthesis process, an L9 Taguchi matrix accommodating 4 parameters at 3 levels each was used, and the obtained data from the 9 experimental combinations (for each catalyst) was used for a comparative evaluation of their catalytic performance. The obtained product showed acceptable physico-chemical properties as is mandated under biodiesel. The use of a catalyzed process also means that the wet washing process involved during downstreaming can contain significant amounts of active leached ions which may prove toxic if disposed without proper treatment.

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