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PRODUCTION OF BIODIESEL FROM WASTE OILS USING TRANSESTERIFICATION METHOD

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ABSTRACT

The rising cost of crude oil combined with growing public concern about the environmental impact of more traditional fuels has heightened interest in finding a long-term, carbon-neutral energy solution. Because of its many advantages over diesel fuel, such as lower greenhouse gas emissions, no sulphur emissions, no particulate matter pollutants, low toxicity, and biodegradability, biodiesel has emerged as a viable alternative. Transesterification process using basic homogeneous catalysis was used to create methylic and ethylic biodiesel from waste frying oils of soybean, canola, maize, and sunflower. The transesterification processes were carried out at 40 degrees Celsius for 40 minutes using 2% of a catalyst (KOH). Once the biodiesel and glycerol phases were separated, the biodiesel was washed with an aqueous solution of 0.1M HCl, heated to 100 degrees Celsius to evaporate any remaining alcohol, and then filtered under vacuum using silica. The reaction yields ranged from 68% to 95%, which is excellent. Oils and biodiesel both had their oxidative stability indices calculated.

Keywords: *Biodiesel, Transesterification, Cooking oil, Waste, Fuels*

I. INTRODUCTION

Energy sustainability, environmental issues, and growing fuel prices are just a few of the challenges of the 21st century. Using conventional fuels results in air pollution due to the release of gases like sulphur dioxide, carbon dioxide, and particulate matter. The result has been more effort put into studying renewable energy and alternative fuels. Moreover, the world's ever-increasing energy demand has led to a decrease in available fuel. Over the past decade, the transportation industry has been responsible for an increasing share of the world's total fuel consumption (61.5 percent). According to the most up-to-date estimates, the world's supply of petroleum will only last for another 46 years. As a result, there's been a rise in the number of studies looking at viable alternatives to diesel made from petroleum. Million percent of India's petroleum fuel needs are met domestically, while the other seventy percent must be imported at a yearly cost of almost Rs. 80,0000 million. It's obvious that adding just 5 percent biodiesel fuel to the current diesel fuel will result in annual savings of 40 million rupees.

In recent years, as political recognition of the effects of global warming has grown, so too has the use of biodiesel (fatty acid methyl esters), which has many advantages over petroleum diesel, including a marked reduction in greenhouse gas emissions, non-sulfur emissions and non-particulate matter pollutants, low toxicity, biodegradability, and the fact that it is obtained from renewable sources like vegetable oils, animal fat, etc. Exhaust emissions, cetane number, flash point, and lubricity qualities are all enhanced when using biodiesel as opposed to fossil diesel fuel. Also, biodiesel provides a return of around 90% more energy than is expended in its production. Using a combination of biodiesel and regular diesel in certain proportions is compatible with and does not require any adjustments to any current conventional compression ignition engine. Biodiesel is currently used as a blend component in a variety of countries, particularly in industrialised nations like the United States, France, and Brazil, due to its renewable nature,

low cost, and greenhouse gas reduction potential. Waste cooking oil and other bio wastes might be utilised as raw material for biodiesel manufacture, and this would allow India to replace 41.14 percent of its total diesel fuel use.

II. WASTE COOKING OIL (WCO)

Used vegetable oil is what is meant by "waste cooking oil." Due to its high free fatty acid (FFA) concentration, edible vegetable oil is rendered unfit for ingestion after being used repeatedly in the frying process. Instead of disposing of waste oil, which can cause water and soil pollution, human health concerns, and disturbances to the aquatic ecology, it can be utilised as a feedstock for Biodiesel production because it is abundant and inexpensive. In addition, wastewater treatment facilities have difficulties in purifying it when it contains fats from animals with a high acid value or sludge that floats because it contains lipids. Therefore, it is an appropriate technique for reducing environmental impacts and can assist solve the energy crisis by converting low quality lipid-rich supplies from slaughterhouses into commercial grade biodiesel. Soaps and lubricating oil additives may be made from collected WCO as well. Many scientists have developed efficient methods for transforming vegetable oil waste into biodiesel.

Saturated hydrocarbons (triglycerides), which include glycerol and fatty acid esters, are found in vegetable oil [8]. Hotel grease, fast food oil, and fritter oil are all sources of used vegetable oil (UVO), as is the byproduct of a working vegetable oil plant. Waste cooking oil is typically discarded untreated in an effort to serve higher quality meals. For example, second-used cooking oil (UCO) from restaurants may be converted into biodiesel and used in other ways besides frying meals for sale on the street. Deodorized palm oil distillate (DDPO) is another potential and inexpensive feedstock. In fact, replacing wasted oil with new oil eliminates the need for food-for-fuel crops and the resulting competition. UCOs are distinct from both refined and crude vegetable oils in their characteristics. Because of the chemical events that take place during frying, such as hydrolysis, oxidation, polymerization, and material transfer between food and vegetable oil, WCO has different chemical and physical characteristics than fresh oil.

III. MATERIALS AND METHODS

Biodiesel Production

The refined oils made from soybeans, canola, sunflower, and corn were purchased in neighbourhood stores and utilised directly. In order to produce biodiesel, some of the oils were used for frying and then recycled. Before undergoing the synthetic method, all used frying oils were filtered to eliminate any remaining debris.

In order to create this, an alkaline transesterification process between methylic and ethylic acids was used. We utilised the Sinth-purchased potassium hydroxide (KOH), methanol (PA), and ethanol (PA) in their purified, unadulterated forms. After adding 1.0 g of KOH to 14 mL of methanol and stirring until it was completely dissolved, the resulting potassium methoxide was produced (exothermic reaction). A solution of potassium ethoxide was produced by dissolving 1.0 g of KOH in 14 mL of a 1:4 (vol: vol) methanol: ethanol combination with constant stirring. As spontaneous phase separation was not achieved when using simply ethanol, the alcoholic combination methanol: ethanol was employed for the ethylic approach. 50 g of oil was added to the alkoxide mixture, and the reaction system was stirred at 40 degrees Celsius for 40 minutes.

After the decantation step, each biodiesel form was separated from glycerin and washed with HCl 0.1M solution in order to monitor the transesterification process using thin layer chromatography (TLC). The separation development in hexane/ethyl acetate 95%/5% solution can exhibit a decrease of oil band and increase of biodiesel bands over time. To eliminate the alcohol, the biodiesel was heated to 100 degrees Celsius before being filtered through a sintered plate glass filter containing silica.

Oxidative Stability Studies

Finding out at what point in time oxidation rates, peroxide indices, oxygen uptake, and the creation of volatile molecules begin is crucial, as is pinpointing the period at which no secondary compounds of oxidation have formed. Metrohm 873 Rancimat equipment was used to test oxidative stability. The oil, methylic biodiesel, and ethyl biodiesel samples were heated continuously at 110°C ± 0.3°C, while exposed to an air gas flow of 10 L/h.

GC-MS Analysis

Biodiesel samples were analysed by gas chromatography using an HP CG 5890 series II gas chromatograph fitted with an HP1 column (100% dimethyl polysiloxane), 30 metres in length, and 0.2 millimetres in internal diameter. Air (300 L/min) and hydrogen and nitrogen (30 L/min) were used as the mobile phase. All measurements were taken using an injection volume of 0.5 µL. The injector temperature was set to 200 degrees Celsius, and a temperature ramp from 80 to 200 degrees Celsius was used for the analysis. Using a mass spectrometer HP model 5988A that was attached to the chromatograph, we were able to see the mass spectra of the major chromatographic peaks.

IV. RESULTS AND DISCUSSIONS

There are two primary arguments in favor of making biodiesel out of used cooking oil scraps: first, the low cost of this waste makes biodiesel production more financially attractive, and second, avoiding the dumping of two different types of garbage into the environment can only be a good thing.

Snack shops, restaurants, and households generate a substantial quantity of used frying oil as trash. Soybean oil is by far the most popular vegetable oil, followed by corn, sunflower, and canola. In this study, we looked into both of these options for making biodiesel. Table 1 displays the reaction yields for each of the 16 different tests.

Table 1: Reaction Yields

Route	**Yields (%)**							
	Soybean		**Corn**		**Canola**		**Sunflower**	
	Ref*	**Was****	**Ref**	**Was**	**Ref**	**Was**	**Ref**	**Was**
Methylic	95,3	95,9	92,7	86,8	94,3	91,0	93,3	93,8
Ethylic	83,3	77,9	81,3	67,8	81,5	78,9	85,7	72,1

*Ref – Refined Oil; ** Was – Waste Oil

Table 1 shows that methylic through consistently produced greater yields than ethylic via for all of the tested processes. For the most part, the biodiesel yield from used oil was lower than that of refined oil in laboratory tests. Waste oils are at a more advanced state of deterioration due to the degradation processes that occur during frying, which is consistent with the results shown in Figure 1. While yields aren't great, the approach suggested here is straightforward and doable for making biodiesel from the most common forms of used cooking oil.

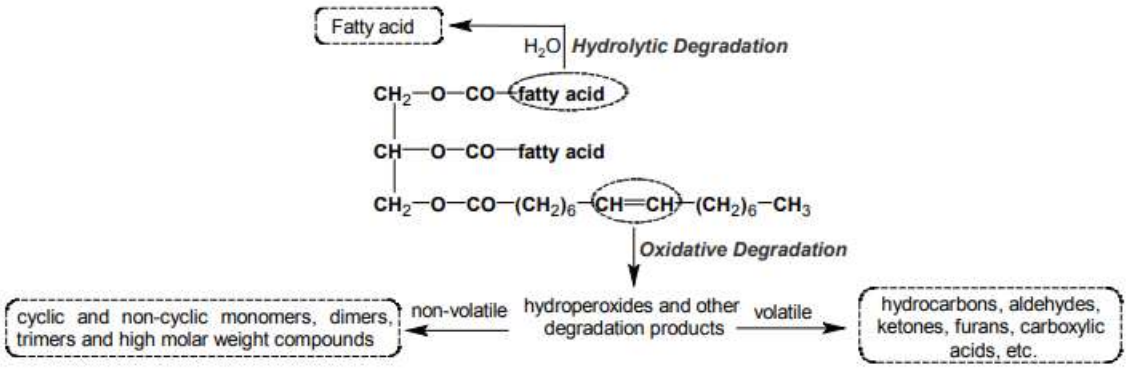

Figure 1: Degradation Process Suffered by Vegetable Oils during Frying

Samples of biodiesel were synthesized and refined before being characterized. By using GC-MS, we determined how well biodiesel samples withstood oxidation and what chemicals were present. The data for the oxidative stability index are shown in Table 2.

Table 2: Oxidative Stability Index Obtained for the Oils and the Methylic and Ethylic Biodiesels

Route	**Yields (%)**							
	Soybean		**Corn**		**Canola**		**Sunflower**	
	Ref	**Was**	**Ref**	**Was**	**Ref**	**Was**	**Ref**	**Was**
Oil	6,67	5,17	9,56	6,34	7,26	4,83	4,44	2,00
MB*	0,12	0,11	0,24	0,12	0,17	0,15	0,14	0,16
EB**	0,12	0,13	0,15	0,18	0,09	0,11	0,11	0,14

*MB – Methylic Biodiesel; **EB – Ethylic Biodiesel

Refined oils and used frying oils were compared using their oxidative stability index. Waste frying oils were found to have a much lower oxidative stability index, providing further evidence that vegetable oils used in immersion frying deteriorate with time. A poor oxidative stability index value (6 hours at 110 degrees Celsius) was found for the biodiesel samples. As a matter of fact, the oxidative stability index for biodiesel rarely surpasses the conventional value of 6 h in most tests, making its poor oxidative stability both a characteristic and an issue to be tackled.

Each and every biodiesel sample was put through a GC-MS analysis. Since the chromatographic profile of the samples allowed for comparable findings, we offer a subset of the resulting chromatograms. The chromatograms for the biodiesel made from corn and canola oil are shown in Figure 2.

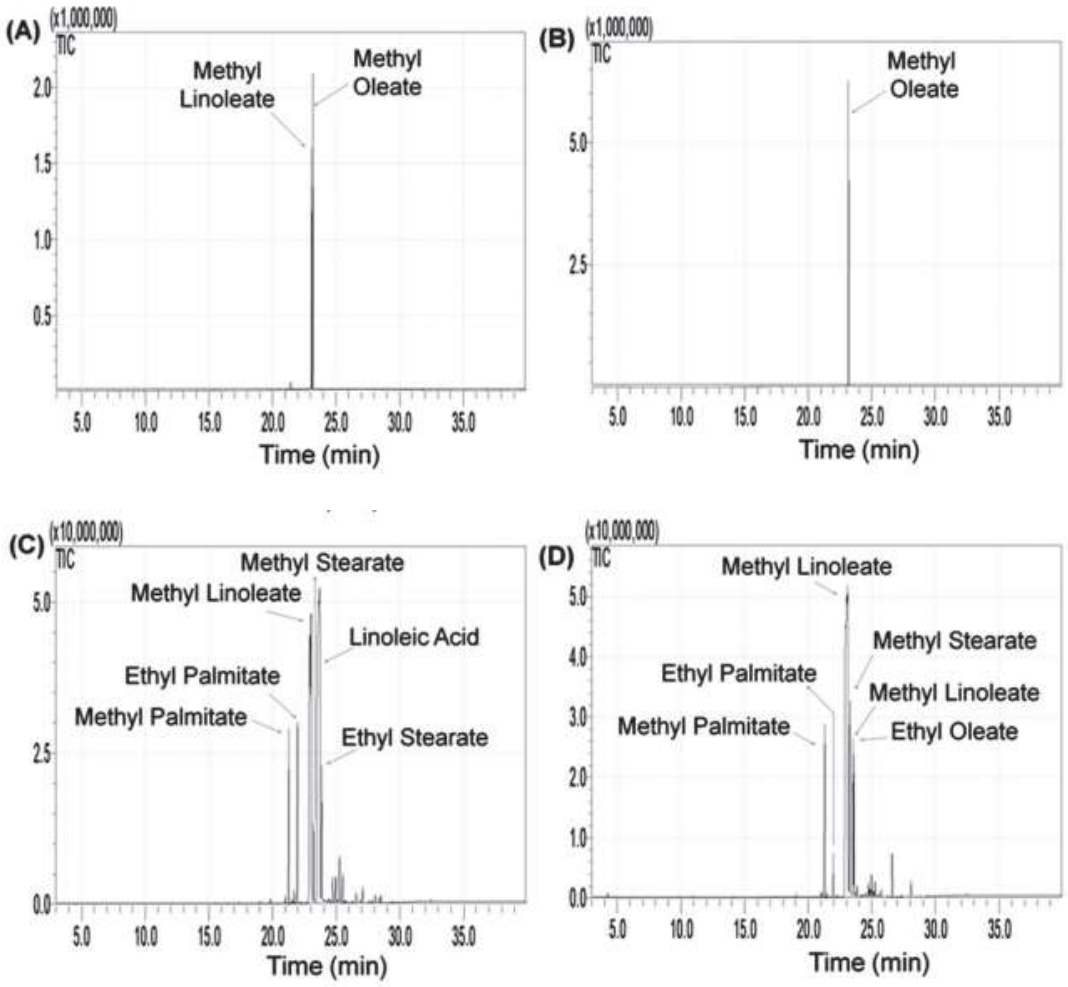

Figure 3: Chromatogram with Mass Spectrum Identification for Biodiesel Sample (A) Methylic Corn Waste Oil, (B) Methylic Canola Waste Oil, (C) Ethylic Corn Waste Oil, (D) Ethylic Canola Waste Oil

Palmitate, oleate, linoleate, and stearate were the most common types of esters (methylic or ethylic) found in all samples, corroborated the success of the synthesis process, and were found in excellent accord with prior research described in the literature (Table 3). It was discovered that the ethylic biodiesel samples had both methylic and ethylic acids, which can be traced back to the use of an alcoholic mixture in the ethylic via.

Table 3: Fatty Acid Composition of Soybean Oil, Canola, Corn and Sunflower

Fatty acid	**Oil**			
	Soybean	**Canola**	**Corn**	**Sunflower**
Palmitic C16:0	12,66 %	3,90 %	12,00 %	6,66 %
Stearic C18:0	3,96 %	1,10 %	2,90 %	4,32 %
Oleic C18:1 (9)	23,61 %	64,40 %	32,20 %	21,09 %
Linoleic C18:2	55,26 %	20,40 %	52,20 %	67,78 %

Linolenic C18:3	4,52 %	9,60 %	0,70 %	0,15 %

V. CONCLUSIONS

Because it is chemically identical to diesel, biodiesel may be used in any diesel engine without any adaptations. It's generated from renewable sources like vegetable oils, animal fat, etc., and has several desirable properties, including high biodegradability, reduced greenhouse gas emissions, no sulphur emissions, no particulate matter pollutants, low toxicity, and good lubricity. The majority of biodiesel is produced by transesterification. Used oil may be a viable feedstock due to its low cost and high potential. As the FFA content of WCO increases, the yield drops. This study demonstrates that waste oils from soybean, maize, canola, and sunflower frying may be used to produce methylic and ethylic biodiesel via the transesterification reaction. Thus, the use of used frying oils seems to be an intriguing alternative for the manufacture of biodiesel, since they can be readily converted to biodiesel and help to the local development of towns wishing to engage in schemes to collect and reuse of this waste.

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