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Research Paper Chemistry

Biodiesel Production From Refined Sunflower Oil and Waste Oil Using Homogeneous Base Catalysts

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ABSTRACT

The prime objective of this paper is to investigate the parametric effects on the biodiesel production such as molar ratio of oil: alcohol, reaction temperature, time, and concentration of catalyst to determine the best conditions required. Biodiesel was prepared from fresh sunflower oil and waste cooking oil by transesterification reaction. The prepared sample complies with EN standard specifications. It was found that the best conditions were alcohol: oil molar ratio of 9:1, 1% KOH as catalyst, reaction temperature 65^{0}C, one-hour reaction time for both raw materials. The samples met with most of the criteria required to be used as a fuel.

KEYWORDS : biodiesel, transesterification, fuel, parametric effect

Introduction

Fossil fuels are providing almost 80% of the world energy requirements [1]. However, fossil fuel reserves are depleting day by day due to the increased growth in population and industrialization [2]. Therefore, the need of the hour is an alternative fuel. Biodiesel production is given utmost importance nowadays because it is a viable alternative fuel to conventional petro-diesel [3].Biodiesel is the only alternative fuel to successfully complete the EPA's rigorous emissions and health effects study under clean air act. Biodiesel provides significantly reduced emission of CO, particulate matter, unburnt hydrocarbons, carcinogenic compounds by as much as 85% [4-7] compared to petroleum diesel fuel.Biodiesel is methyl ester of higher fatty acid, can be obtained by transesterification reaction of triglycerides with methanol in presence of a catalyst [8,9] and Glycerol is the by-product formed. Generally, homogeneous base catalyst such as NaOH or KOH are the most suitable catalyst for transesterification reaction since they catalyse the reaction faster than acid catalysts [10,11]. The aim of this investigation is to study the optimum conditions which can produce best quality biodiesel with high efficiency from fresh vegetable oil and waste oil by the process of transesterification.

Materials and Method

Materials

Refined sunflower oil and waste oil from canteen were used. One mole of both fresh oil and waste oil were used for all the experiments. Chemicals used for the reaction are KOH, NaOH, methanol and distilled water.

Transesterification reaction

Experiment was carried out in a round bottom flask. The specific amount of catalyst was dissolved with the specific volume of alcohol. Oil was preheated to a temperature of 65^{0}C while stirring with magnetic stirrer and then the mixture was added to the oil slowly. After that, the mixture was left in separating funnel to separate the mixture into different layers. As glycerol has higher density than biodiesel, it forms the bottom layer and biodiesel the top layer. Glycerol was then taken out and biodiesel was washed with distilled hot water till a pH of 7 was obtained. It was then dried by applying heat for an hour.

Results and discussion

Characterization of vegetable oil

Table-1 shows the properties of the sunflower oil used in this study and its free Fatty acid content.

Table 1
Properties of Sunflower Oil

Density (at 25^{0}C)	920.5 Kg/m^3
Kinematic Viscocity (at 40^{0}C)	53.87 cSt
Water content	0.09 Wt.%
FFA content	0.22 Wt.%

Experiment Condition and Result

Oil samples were subjected to different conditions to find the optimum conditions to get maximum biodiesel yield. The results are given in Table-2.

Figure-1 indicates how the Alcohol: Oil molar ratio effect the yield of biodiesel produced. The lowest yield was achieved when alcohol to oil molar ratio was 3:1. There was dramatic increase in the yield from 91.00% to 96.69% when the alcohol to oil molar ratio was increased to 6:1. There was further increase in the yield when the ratio was increased to 9:1. Since the reaction is in equilibrium, Le Chatlier's principle can be applied for the analysis.

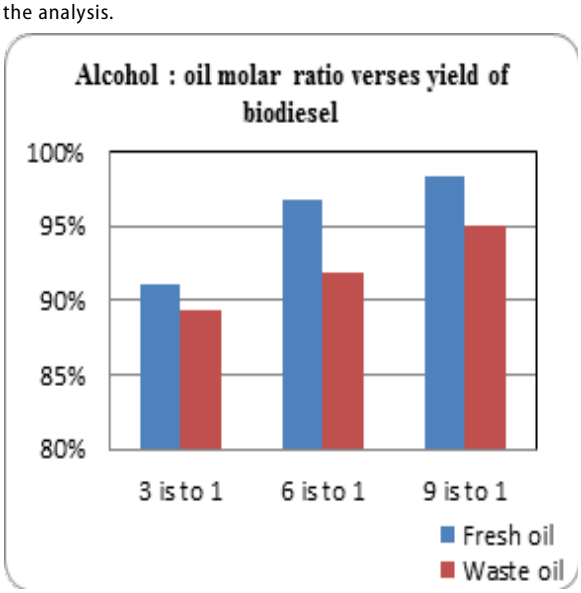

Figure 1

According to Le Chatlier's principle, in an equilibrium reaction the rate of forward reaction can be increased by increasing the concentration of one of the reactants.

TABLE 2
EXPERIMENT CONDITIONS AND RESULTS

Fresh oil								
Catalyst & Conc.	Alcohol: oil molar ratio	Vol. of Alcohol (ml)	Vol. of Oil (ml)	Reaction temp. (^{0}C)	Reaction Time	Yield (ml) 1st	Yield (ml) 2nd	% Yield
KOH, 1%	6: 1	244.0	307.7	65	1h	300	295	96.69
KOH, 1%	9: 1	366.0	307.7	65	1h	305	300	98.31
KOH, 1%	3: 1	121.2	307.7	65	1h	280	280	91.00
KOH, 1%	6: 1	244.0	307.7	25	1h	265	260	85.31
KOH, 1%	6: 1	244.0	307.7	65	0.5h	270	270	87.75
KOH, 0.5%	6: 1	244.0	307.7	65	1h	260	270	86.12
NaOH, 1%	6: 1	244.0	307.7	65	1h	280	285	91.81
Waste oil								
Catalyst & Conc.	Alcohol: oil molar ratio	Vol. of Alcohol (ml)	Vol. of Oil (ml)	Reaction temp. (^{0}C)	Reaction time	Yield (ml) 1st	Yield (ml) 2nd	% Yield
KOH, 1%	6: 1	244.0	307.7	65	1h	285	280	91.81
KOH, 1%	9: 1	366.0	307.7	65	1h	290	295	95.06
KOH, 1%	3: 1	121.2	307.7	65	1h	275	275	89.37
KOH, 1%	6: 1	244.0	307.7	25	1h	250	240	79.62
KOH, 1%	6: 1	244.0	307.7	65	0.5h	255	265	84.50
KOH, 0.5%	6: 1	244.0	307.7	65	1h	255	250	82.06
NaOH, 1%	6: 1	244.0	307.7	65	1h	270	275	88.56

The data shows that the trend follows the principle. KOH gave higher yield compared with NaOH when used as a catalyst.

Applying low temperature gave the lowest yield of 85.31% among any other variables. Practically, slow rate of reaction was observed when temperature was lowered. According to the trend, it appears that the forward reaction is favored in the equilibrium reaction when higher temperature is applied. Although not tested, the forward reaction will further accelerate when higher temperature is applied, but then the saponification reaction between triglyceride and catalyst might be accelerated as well [12]. Loss of methanol will occur if temperature higher than the boiling point of alcohol is applied. Yield of biodiesel is found to increase with increase in time of the reaction but considering the consumption of fuel or electricity to supply heat, the reaction more than an hour is not economical.

Properties of the Synthesized Biodiesel

The properties of the synthesized biodiesel from refined oil at optimal conditions using KOH and NaOH catalyst were determined (Table-3)

Table 3
BIODIESEL PROPERTIES

Property	Biodiesel from Fresh oil	Biodiesel from Waste oil
Iodine value	125.0	108.2
Density	0.7 g/cc	0.8 g/cc
FFA	0.84%	0.19%
Phosphorus content	10 ppm	6 ppm
Flash point	145°C	140 °C
Viscosity (at 40°C)	2.9mm^2/s	3.2mm^2/s
Pour point	10°C	10 °C

Conclusion

Considering all the changes, the optimum reaction conditions to get the best yield is 9:1 alcohol to oil molar ratio, 1%KOH as catalyst, 65^{0}C reaction temperature and one hour reaction time. However, considering that the yield does not substantially increase when the molar ratio increases beyond 6:1, as not all the alcohol is used in the reaction – the recovery of alcohol has to be carried out which will not be economical. And as the reaction is incomplete when the alcohol to oil molar ratio is 3:1, the condition is out of option. It was found that fresh vegetable oil gives the best result and yield. KOH gave higher yield compared with NaOH when used as a catalyst. The properties of prepared biodiesel are found to be close to European Standard specifications.

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