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Biodiesel Synthesis from Karanja Oil Using Transesterification Reaction

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A process for the production of the ethyl ester from Karanja oil to use as a biodiesel fuel has been studied. The essential part of the process is the transesterification of Karanja oil using methanol. NaOH is used as catalyst to yield methyl ester of Karanja oil as a product and glycerol as a by-product. Experiments have been performed to determine the optimum conditions for the preparation of ester. The process variables were temperature, catalyst, methanol used. Further the engine performance of biodiesel were checked with petroleum diesel and found almost identical.

Key Words: Transesterification, Biodiesel, Karanja oil, Catalyst.

INTRODUCTION

Vegetable oils have attracted attention as a potential renewable resource for the production of fuel. Transesterification products derived from vegetable oils have been recognized as an alternative fuel for diesel engines, including neat vegetable oil, mixtures of vegetable oil with petroleum diesel fuel and alcohol esters of vegetable oils. Alcohol esters of vegetable oils appear to be the most promising alternative[1]. Vegetable oils are triglycerides glycerine esters of fatty acids; alcohol esters of fatty acids have been prepared by the transesterification of the glycerides, wherein linear, mono hydroxy alcohols react with vegetable oils in the presence of a catalyst to produce alcohol esters, which is a known biodiesel[2].

Alternative fuel studies are driven by the need for new energy sources and the need to protect the environment. Biodiesel is biodegradable and non-toxic, has low emission problems and so it is environmentally beneficial[3]. Biodiesel is a chemically produced methyl esters from vegetable oil to replace the traditional diesel fuel. The chemical process is known as transesterification and consists of treating vegetable oils, like soybean,

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sunflower and rapeseed, with reactants (methanol or ethanol) to obtain a methyl or ethyl ester and glycerol. In transesterification, one ester is converted to another. The reaction is catalyzed by a reaction with either an acid or base and involves a reaction with an alcohol, typically methanol, if a biodiesel fuel is the desired product[4]. Fats and oils are made up of 1 mol of glycerol. Various authors[5-8] have studied fuel properties of different oil esters and also studied the power and emission characteristics.

EXPERIMENTAL

Karanja oil was procured from local market, which has the specification as shown in Table-1. Ethanol and potassium hydroxide pellets was procured from S..D. Fine Chemicals India.

TABLE-1
PHYSICAL AND CHEMICAL PROPERTIES OF KARANJA OIL

Specification	Properties
Viscosity	52.6 cp
Specific gravity	0.917/0.923
Flash point	110/340ºC
Carbon residue	0.64%
Distillation point	284-295 ºC
Sulfur	0.13-0.16%
Specification value	188-198
Refractive index	1.47

Experimental setup and procedure: The transesterification experiments were performed in conical flasks using 250 g of Karanja oil as shown in Fig. 1. The required catalyst based on the stoichiometric amount was dissolved in the methanol as per requirement of transesterification. The methanol and dissolved catalyst were then added to the oil and stirring was begun. Samples of *ca.* 5 mL of the reaction mixture were pipette out after equal intervals. The reaction was arrested in the samples by adding one or two drops of water. The samples were analyzed to determine the degree of completion of the reaction. Experiments were conducted to study the effects of temperature and sodium hydroxide catalysts on ester yields. Experiments were also performed to determine effect of stirring speed. After 2 h of reaction time, the reaction was stopped and the reaction mixture was allowed to stand overnight while phase separations occurred. The ester phase was then decanted from the equilibrium mixture; the ester product formed the upper layer and the by-product glycerol formed the lower layer. The residual catalyst and unreacted excess alcohol were distributed between the two phases. After separation of the phases, the catalyst and alcohol were washed from the ester with water.

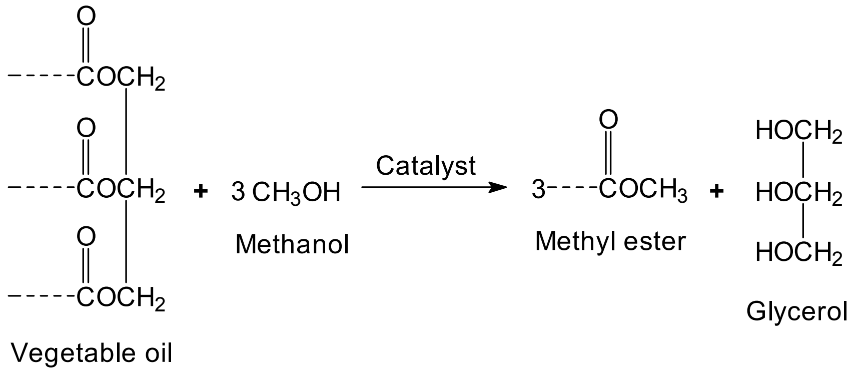

Fig. 1. Transesterification reaction

Transesterification reaction: Transesterification is the most commonly used method for the production of bio-diesel from vegetable oils. Generally vegetable oils are fatty acid esters of triglyceride. In transesterification reaction, oil is reacted in presence of ethyl or methyl alcohol and NaOH or KOH as a catalyst. During reaction methyl group gets substituted for glyceride group and get ethyl on ethyl ester as a product. Fig. 1 shows most common transesterification reaction

Engine performance: Testing of biodiesel was carried out on 4-stroke diesel engine. The specifications of the engine were 2 cylinder diesel engine producing 10 HP at 1500 rpm, with Dynometer of 10 KV capacity.

RESULTS AND DISCUSSION

Initially the reaction was carried out at different temperatures in the range of 50-75 ºC. Keeping the other parameters constant such as oil composition, reaction time. Optimum temperature was noted and was found 65 ºC. At this temperature the yield of raw biodiesel was found maximum and further increase in the temperature, there is no significant improvement in the biodiesel output was observed as indicated in Fig. 2. The complete formulation and output of downstream products are enlisted in Table-2.

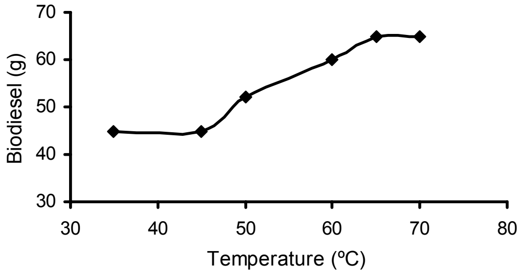

Fig. 2. Effect of temperature on the raw biodiesel production

TABLE-2
OPTIMIZATION OF THE REACTION TEMPERATURE FOR THE BIODIESEL OUTPUTS

Composition			Reactions parameters		Product layer		Biodiesel washing rate (mL)	Final biodiesel produce	Soap water (mL)
Oil	Methanol (g)	NaOH (g)	Reaction stirring time (min)	Temp. (ºC)	Biodiesel (g)	Bottom (g)			
100	25	0.5	120	35	45	75	200	40	204
100	25	0.5	120	45	45	75	200	40	205
100	25	0.5	120	50	52	68	200	47	205
100	25	0.5	120	60	60	57	200	52	205
100	**25**	**0.5**	**120**	**65**	**65**	**52**	**200**	**59**	**205**
100	25	0.5	120	70	65	50	200	58	205

It has been observed that with increase in the catalyst concentration, there is an increase in the biodiesel output. It has been found that the optimum conversion is at the concentration of 0.6 g, further addition of catalyst concentration, biodiesel output was found decreasing (Fig. 3). The complete formulation and output of downstream products are enlisted in Table-3. As shown in Fig. 4 increasing the methanol concentration there is continuous increment in the biodiesel output upto the 45 g of methanol. Further increase in methanol concentration the biodiesel production becomes almost constant.

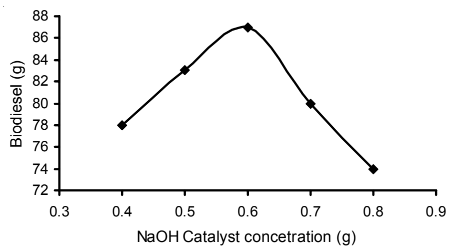

Fig. 3. Effect of NaOH catalyst concentration on the biodiesel production

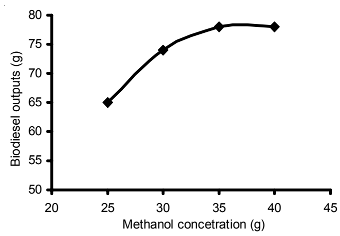

Fig. 4. Effect of methanol concentration on the biodiesel outputs

Test performance of Biodiesel: Tables 4-6 show test performance of biodiesel in comparison with the petroleum diesel. it has been found that the there is no significant difference in comparison with the petroleum diesel and the petroleum diesel can be completely replaced using biodiesel.

TABLE-3
OPTIMIZATION OF THE NaOH CONCENTRATION FOR THE BIODIESEL OUTPUTS

Reaction					Product layer				
Oil	Methanol (g)	NaOH (g)	Reaction string time (min)	Temp. (ºC)	Biodiesel (g)	Bottom (g)	Biodiesel washing rate (mL)	Final biodiesel produce	Soap water (mL)
100	35	0.4	120	65	78	49	200	72	205
100	35	0.5	120	65	83	41	200	73	208
100	**35**	**0.6**	**120**	**65**	**87**	**25**	**200**	**74**	**210**
100	35	0.7	120	65	80	30	200	72	217
100	35	0.8	120	65	74	32	200	72	225

TABLE-4
TEST PERFORMANCE OF PETROLEUM DIESEL IN DIESEL ENGINE

Break power (kw)	Fuel consumption (kg/h)	Mech efficiency (%)	Indicated thermal efficiency (%)
2.62	4.05	64.88	24.94
3.42	4.85	70.64	28.46
4.81	6.20	77.18	29.3
6.28	7.10	81.52	28.93
6.75	8.92	84.03	31.87

TABLE-5
TEST PERFORMANCE USING BIODIESEL
[50 % BIO-DIESEL AND 50 % DIESEL]

Break power (kw)	Fuel consumption (kg/h)	Mech efficiency (%)	Indicated thermal efficiency (%)
1.62	4.12	39.80	13.00
3.71	5.61	55.00	16.30
4.62	7.12	64.20	18.29
6.00	8.50	70.58	20.29
6.78	9.28	73.00	21.58

TABLE-6
TEST USING BIO-DIESEL [100 % BIODIESEL]

Break power (kw)	Fuel consumption (kg/h)	Mech efficient (%)	Indicated thermal efficiency (%)
1.62	4.12	46.20	12.00
3.21	5.11	55.00	14.32
4.67	6.57	64.20	16.50
6.00	7.90	70.58	18.56
6.96	8.86	73.00	21.58

The thermal efficiencies of 50 % biodiesel blend also, show the same value. Hence the complete replacement is possible without change in the accessories of actual petroleum diesel engine. It also compare biodiesel with petroleum diesel in the physical and chemical properties, It has been found that the calorific value of the biodiesel is almost same. There is large difference in the output of carbon residue; biodiesel gives almost less residual carbon in comparison with the petroleum diesel.

TABLE-7
COMPARATIVE PROPERTIES OF BIODIESEL WITH PETROLEUM DIESEL

	Units	Biodiesel sample	Petroleum diesel
Density at 30 ºC	9/mL	0.88	0.85
Combustor point	ºC	192	65
Kinetic viscosity	cSt	4.84	2.80
Calorific potential	MJ/kg	41	45
Cetane number	–	-	47.50
Ester content	%	799	0
Sulfur content	%	0	< 0.50
Carbon residue	%	0.024	< 0.35
Cloud point	ºC	-1.1	-
Pour point	ºC	-14	-

Conclusion

With increase in the catalyst concentration there is an increase in the biodiesel output, it shows the optimum value at the concentration of 0.6 g, further increase in the catalyst concentration the biodiesel output was found decreasing.

Complete replacement petroleum diesel is possible without change in the accessories of actual petroleum diesel engine. It has been found that the calorific value of the biodiesel is almost same. There is large difference in the output of carbon residue; biodiesel gives almost less residual carbon in comparison with the petroleum diesel.

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