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Transestrification of Karanja (*Pongamia Pinnata*) Oil

KEYWORDS: Transestrification, Karanja biodiesel, molar ratio, catalyst

SRIRAMAJAYAM, S.

Department of Bioenergy, AEC&RI, Tamil Nadu Agricultural University, Coimbatore - 641003, Tamil Nadu

ABSTRACT *The objective of the present work is to produce biodiesel from non edible karanja vegetable. The optimal conditions for best yield of biodiesel from karanja were observed with molar ratio of 1:7.5, catalyst amount of 0.3M and reaction time of 2h. The calorific value for biodiesel was 39.81 MJ/kg. The kinematic viscosity of biodiesel from karanja oil at 40oC was found to be 5.59 mm2/s. The flash point, cloud point and pour point were 163°C, 14°C and 1°C, respectively. All the biodiesels produced in the present study met the BIS standards.*

Transesterification technology provides biodiesel as a renewable fuel and glycerol as a byproduct, which can be a raw material for different chemical products. The biodiesel is biodegradable, non-toxic, has low emission profiles and environmental friendly (Krawczyk, 1996). Biodiesel has low sulphur content and releases lower CO during combustion in diesel engines (China et al., 2005; Puhan et al., 2005). Biodiesel contains oxygen, which leads to complete combustion in internal combustion (IC) engines. For developing countries fuels of bio-origin can provide a feasible solution to this crisis. Certain edible oils such as cottonseed, palm, sunflower, rapeseed, and safflower can be used in diesel engines. For longer life of the engines these oils cannot be used straightway. These oils are not cost effective to be used as an alternate fuel in diesel engines at present. Some of the non-edible oils such as castor, rice bran, linseed, karanja (*Pongamia glabra*), jatropha and neem, madhuca, rubber etc. can be used in diesel engines after some chemical treatment. The viscosity and volatility of these vegetable oils is higher, and these can be brought down by a process known as "transesterification". The characteristics of biodiesel reduce the emissions of carbon monoxide (CO) in the exhaust gas as compared with petroleum diesel (Agarwal, 1998; Agarwal & Das, 2001).

MATERIALS AND METHODS

For testing the properties of raw oil and their biodiesel the standard methods were adopted *viz.*, Calorific value (IS: 1448-1960), Kinematic viscosity (ASTM 445-72), Specific gravity (IS: 1448-1972), Flash point (IS: 1448-1992), cloud and pour point (ASTM D-97/57), Carbon residue (ASTM D524-IP14/65), Ash content (IS: 1448-1992), Free fatty acid and acid value (AOCS Ca 5a-40), Iodine value (AOCS Cd 1c-85) and Saponification value (AOAC)

2.1. Experimental details

The experimental conditions used for production of biodiesel from karanja oil with molar ratio (1:4.5, 1:6 and 1:7.5), catalyst amount (0.1, 0.2 and 0.3 M) and 2 h reaction time.

Initially a reaction time of 2 h was used for transesterification of oil and then the reactants were poured into separating funnel and kept for 12h to separate the glycerol. Glycerol settled at the bottom and the crude biodiesel above the glycerol layer was collected. The collected biodiesel was washed three times with water and the glycerol content in biodiesel was determined by A.O.C.S Ca14-56 method. The methyl ester conversion was calculated based on glycerol content in the crude oil and biodiesel.

RESULTS AND DISCUSSIONS

i. Optimal conditions for biodiesel production

For this study three levels of molar ratios and catalyst amount were used to determine the optimal conditions for higher methyl ester conversion in biodiesel production. The molar ratio of oil to methanol is an important parameter in biodiesel production. For this study, three levels of molar ratios (1:4.5, 1:6 and 1:7.5) were used.

At 1:4.5 molar ratio of oil to methanol, the methyl ester conversion increased from 82.63 to 89.50% (Figure 1) as the catalyst amount increased from 0.1 to 0.3 M. At 1:6 molar ratio, the methyl ester conversion raised from 91.20 to 94.73% as catalyst amount increased from 0.1 to 0.3M. For 1:7.5 molar ratio, the methyl ester conversion increased with molar ratio as well as with catalyst amount. The best conversion occurred at a molar ratio of 1:7.5 with 0.3 M catalyst amount.

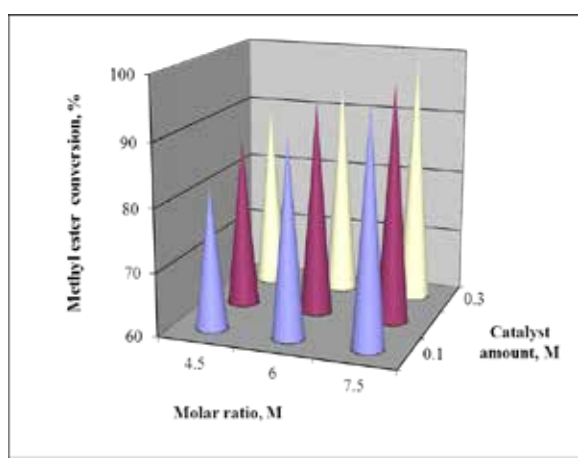

Figure 1. Effect of molar ratio and catalyst amount on karanja biodiesel production

ii. Properties of raw oils and their biodiesel

The properties of biodiesel produced from karanja is compared with ASTM, Indian Standards (BIS) and EN standards and presented in Table 1.

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Table 1. Comparison of properties of Karanja biodiesel with different standards

Property	Karanja Oil	Karanja Biodiesel	Biodiesel standards		
			ASTM	DIN 51606	BIS 15607: 2005
Calorific value, MJ/kg	40.00	39.81	-	-	-
Kinematic viscosity at 40°C, mm^2/s	41.89	5.59	1.9-6.0	3.5-5.0	2.5–6.0
Specific gravity	0.9102	0.8714	0.88	0.875-0.890	-
Flash point, °C	228	163	130 min.	>110	120 min.
Cloud point, °C	15	14	-3 to 2	-	-
Pour point, °C	2	1	-15 to 10	-	-
Carbon residue, %	0.51	0.25	<0.50	<0.5	-
Ash content, %	0.017	0.012	-	-	-
Free Fatty Acids, %	4.40	1.1	-	-	-
Acid value	8.756	2.189	0.8	0.5	0.5 max
Iodine value	90.0	92.5			
Saponification value	194.6	191.8			

Calorific values of biodiesel were slightly lower than raw oils due to chemical changes after transesterification process in fatty acid compositions of oil. The calorific value of karanja biodiesel was 39.81 MJ/kg. In karanja oil the viscosity was reduced from 41.89 to 5.59 mm^2/s after trans-esterification and washing. Viscosity of biodiesel was found to be 1.15 times higher than that of diesel fuel (4.86 mm^2/s). Kinematic viscosity of biodiesel was found within the requirements of DIN standards.

Specific gravity of biodiesels varied from 0.8714 at 40°C, which was comparable to DIN standards (0.875 to 0.890) whereas the specific gravity of original oils was observed as 0.9102 and the similar results were reported by Ali et al. (2008). After transesterification, specific gravity of biodiesel was lower than that of oils due to removal of glycerol from triglycerides.

Flash point of biodiesel and raw oil was 163°C and 228°C, respectively. The lower flash point temperature of biodiesel indicates an improvement in volatile property of the biodiesel. This may be due to the replacement of the glycerol by molecules of methanol in the fatty acid compositions of the biodiesel. Even though the flash points of these biodiesels as higher than diesel fuel, they meet out the IS standards for biodiesels (>110°C).

Cloud point of biodiesel was observed to be 14°C and it was slightly lower than that of raw oil (15°C). This may be due to changes in composition of biodiesels by transesterification. The pour point of biodiesel was 1°C, which was 2°C for raw oil. The decrease in pour point of biodiesel may be due to variation in the fatty acid compositions.

Carbon residue is an important property for indicating the coking characteristics of fuel. The carbon residue for biodiesel must be lower than 0.50% (DIN Standards) for better engine performance. Carbon residue of biodiesel was 0.25%, which was 0.51% for raw oil. This range was found to be within the acceptable range of biodiesel standards. Ash content of biodiesel was 0.012%, which was 0.017% for raw oil. The reduction in ash content was due to change made in compositions after reaction and removal of glycerol from the oils.

Impurity present in the biodiesels is revealed by the chemical properties of biodiesels. The free fatty acid of biodiesel was 1.1 %. The free fatty acid of their raw oil was 4.4%. The free fatty acid of biodiesel was lower than raw oils. This may be due to neutralization of free fatty acids by excess amount of NaOH catalyst during biodiesel production process. Acid value of biodiesels was lower than DIN biodiesel standards. Iodine value of biodiesel was 92.5. Saponification value in case of standard diesel was zero as it has no fatty acid. The saponification value of biodiesel was 191.8. All the biodiesels produced in the present study met the BIS standards.

CONCLUSIONS

By transesterification a maximum methyl ester conversion of 98.88% was obtained for karanja oil. The molar ratio of 1:7.5, catalyst amount of 0.3 M and reaction time of 2 h were found to be the optimum conditions for karanja biodiesel production. All the biodiesels produced in the present study met the BIS standards.

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