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Comparative Study on Biodiesel Production from Different Feed Stocks

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Biodiesel is produced from lipid feed stocks. The biodiesel production technology would vary according to the quality of feedstock. In this study, biodiesel production was carried out in vegetable oils from coconut, palm and *Jatropha curcas*. Effect of process parameters such as oil to alcohol ratio and catalyst concentration on biodiesel production was investigated. The optimal conditions for processing of palm and coconut oil were: temperature 60°C; oil to methanol molar ratio of 1:6 and sodium hydroxide of 1 and 0.6%, respectively. The high free fatty acid (8.89% as oleic acid) content *J.curcas* oil was pretreated using 2% H_2SO_4 with 1:6 oil to methanol molar ratio at 50°C for 1 h. The free fatty acid reduced *Jatropha curcas* oil was processed at 1:6 oil to methanol molar ratio and 0.75% NaOH for 2 h at 60°C. Under these optimum conditions the yield of monoester from palm, coconut and *J.curcas* oil were, 97.50%, 94.10% and 96%, respectively.

Keywords: Biodiesel, Free fatty acid, Transesterification.

Biodiesel is one of the renewable fuels, produced from vegetable oils and animal fats through the process of transesterification. It is the reaction of triglycerides in the vegetable oil with alcohols to produce esters and glycerol as a by-product. In the ester production, quality of oil, oil to alcohol ratio, percentage of catalyst, reaction time and reaction temperature are essential process parameters to attain a maximum yield of biodiesel.

At present, raw materials for producing biodiesel is refined or semi-refined vegetable oil from soybean, sunflower, mahua, rapeseed, tobacco seed, rice bran, palm, peanut, jatropha, pongamia, microalgae, waste cooking oil, waste tallow and other cheap materials (Bao *et al.*, 2008). In our country, the non-edible oils namely, jatropha and pongamia, micro algae, waste-cooking oil and waste tallow are suitable for the biodiesel production. Quality of these oils namely, free fatty acid (FFA) and moisture content play a predominant role in determining the pathway of biodiesel production. To produce biodiesel through base transesterification, the FFA and moisture content should be less than 5 and 0.5%, respectively (Gerpen *et al.,* 2005 and Goff *et al.*, 2005). Cooking oils, animal fats and vegetable oils stored for a longer period have higher FFA. These oils would not be directly used in transesterification. To convert these oils into biodiesel a prior step is required i.e., pretreating these high fatty acids using an acid catalyst that prevents the formation of soaps (Veljkovic *et al.*, 2006). Using acids such as sulphuric acid and hydrochloric acid, the FFA content can be reduced to a level of 1-2%. This pretreated oil can be used in the base transesterification, to produce biodiesel.

The alcohols used for the transesterification process are, methanol, ethanol, propanol, butanol etc. Among these, methanol was used widely, due to its faster reaction rate and cheaper than other alcohols. In the transesterification, as per stoichiometry, 3 mole of methanol will be sufficient to produce esters but double the actual requirement will be supplied in the reaction to attain complete conversion of triglycerides into esters. The catalysts used for the biodiesel production are sulphuric acid and sodium hydroxide in the acid and base conditions, respectively. Process temperature depends on the boiling temperature of the alcohol is used in the transesterification process.

Materials and Methods

In this study, oil from Jatropha curcas, palm and coconut are analyzed and the parameters such as, oil to alcohol ratio and percentage of catalyst were optimized to attain the maximum yield of biodiesel.

Free fatty acid content of the oils is analyzed as per standard method AOCS Ca 5a-40. The reaction was carried out in the transesterification reactor. Methanol was used as an alcoholic agent; sodium hydroxide and sulphuric acid are used as catalyst in the transesterification and esterification process, respectively. The coconut and palm oil were pre heated to 60°C then the methoxide solution was

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added and the reaction was carried out for a period of 2 h with a mixing intensity of 200 rpm.

In the case of J. curcas oil, sulphuric acid (2%) was added to methanol (20-25%) and the mixture was heated to 50°C. The acid catalyzed oil was warmed up and it was subjected to transesterification for a period of 2 h at 60°C. After 2 h, the mixture was transferred to a separating funnel and allowed to settle over night by gravity. The biodiesel was decanted from the separating funnel and glycerol was drained out.

Results and Discussion

Free Fatty acid content of the oils

The coconut oil and J. *curcas* oil had an FFA of 0.65 and 8.89% as oleic acid, respectively. The palm oil had 0.92% FFA as palmitic acid. The maximum FFA level for the biodiesel production through base transesterification is 5%. The FFA of coconut and palm was within the permissible limit, so they were directly used in the transesterification process. In J.curcas oil, the FFA content was not within the preferred limit. Hence, the acid esterification was carried out to produce biodiesel from this oil.

Biodiesel production from palm oil

From Fig. 1, it is inferred that the maximum yield of biodiesel was arrived at a methanol concentration of 20%. In the case of 14% methanol the yield of

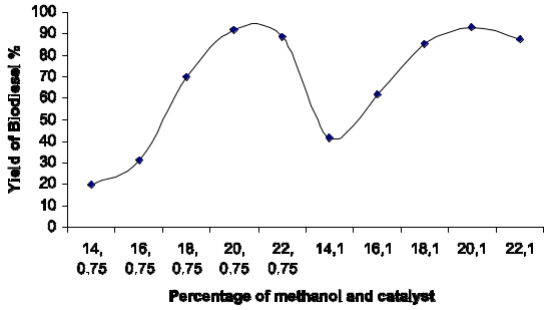

Fig. 1 Effect of methoxide concentration on the yield of biodiesel from palm oil

biodiesel was less as 19.4%. This may be due to the evaporation losses occurred in the reaction. While increasing the proportion of methanol beyond 20% (as double the requirement), the yield was reduced slightly. The methanol is polar in nature; methanol and glycerol both have an equal replaceable hydrogen atom. Due to these reasons, the methanol will mostly bind to the glycerol phase. Hence, the net alcohol supplied in the reaction is not sufficient and it may not be favored the forward reaction and hence it would have been yielded a lesser quantity of biodiesel.

Biodiesel production from coconut oil

Results of the coconut biodiesel production is given in Table 1. A maximum biodiesel production of 94.1% was obtained at a methanol to oil ratio of 20% and a catalyst concentration of 0.6%. Increasing the alcohol to oil ratio beyond this limit significantly reduced the yield of biodiesel.

Table 1. Effect of methanol on the yield of coconut biodiesel

Volume of methanol (%)	Yield of Biodiesel (%)
14	23.0
16	49.2
18	83.3
20	94.1
22	89.6

Biodiesel production from J.curcas oil

The *J.curcas* oil had a FFA content of 8.89% as oleic acid. This is not suitable for the biodiesel production using base transesterification. Higher, FFA content leads to formation of more soaps and the separation of biodiesel becomes complicated process. Hence, the oil was pretreated with sulphuric acid and the pretreated oil was transesterified using sodium hydroxide.

Acid pretreatment of J.curcas oil

The effect of methanol to oil molar ratio and catalyst concentration on reduction of FFA were presented in Table 2. From this, an increase in the methanol concentration from 20 to 25%, promoted the esterification and increase in the catalyst concentration reduced the free fatty acid content of

Table 2. Acid treatment of J.*curcas* oil

Volume of methanol (ml)	Volume of H_2SO_4 (ml)	Pretreated oil		FFA of the pretreated oil
		Volume (ml)	% of raw oil	
100	5	445	89.0	1.45
100	5	442	88.4	1.60
100	5	447	89.4	1.50
100	10	455	91.0	0.730
100	10	457	91.4	0.770
100	10	460	92.0	0.760
125	10	473	94.6	0.592
125	10	472	94.4	0.603
125	10	474	94.8	0.621

the oil to a lower level of 0.5%. While comparing these cases, the free fatty acid content of the oil was reduced to a lower level and a maximum conversion was achieved at the higher catalyst concentration and higher percentage of methanol, respectively.

Alkali treatment of pretreated oil

This data revealed that the ester yield increased with increasing methanol concentration from 20 to 25% and reducing catalyst proportion from 1 to 0.75%. Reducing the catalyst concentration below 0.75% reduced the yield of biodiesel. The results are presented in Fig 2. The higher yield of biodiesel at increased methanol proportion may be attributed that excess quantity of methanol shifts the reaction to ester formation, as transesterification and esterification are reversible reactions. The same results were observed in the studies of Yun *et al.,*

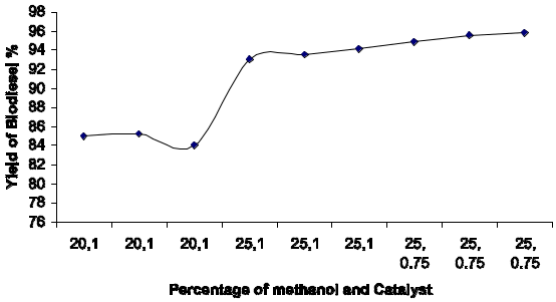

Fig. 2 Effect of methoxide concentration on the yield of biodiesel from *Jatropha curcas* oil

(2008). The transesterification conditions in the present study was 60°C with 0.75% catalyst using 6:1 methanol to oil molar ratio for 2 h yielded 95.4% biodiesel. This is in comparison with the biodiesel yield of 95% as reported by Agarwal et al., (2008) at 55°C with 0.75% catalyst using 9:1 methanol to oil molar ratio.

Conclusion

The variety of feed stocks can be used in the biodiesel production. The ester production from palm, coconut and J.curcas oil is 97.50, 94 and 96%, respectively. The oils with lesser free fatty acid can be transesterified using conventional alkali catalyzed process, but this is not suitable for low cost higher free fatty acid feed stocks especially the animal fats and stored vegetable oils. Pretreatment processes using sulphuric acid had shown a good conversion yields and high quality fuels. Hence, this is an effective method to produce biodiesel from feed stocks that are often considered as waste. Extensive use of these biomass resources would reduce the dependence of fossil fuels and their toxic emissions.

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