Transesterification Of Kapok Oil Using Calcium Oxide Catalyst: Methyl Esters Yield With Catalyst Loading

Yunusa Tukur, Haruna Ibrahim

Abstract: This investigation was necessitated to find other feedstocks for biodiesel production that would not compete with food. Kapok oil with 0.8 FFA was transesterified with methanol using a heterogeneous catalyst, CaO to determine its potential for biodiesel production. Methyl esters yields of 70.4, 65.6, 78.2, 71.9 and 72.5% were obtained with catalyst loading of 0.8, 1.2, 1.6, 2.0 and 2.4% (wt. of oil). The products had high compositions of FFA and alcohols which indicates that the oil require more esterification to reduce the feedstock FFA far below 0.8. Some unsaturated hydrocarbons such as alkenes and alkynes were also formed which could make the products unstable.

Index Terms: kapok oil, methyl esters, transesterification, yield

1 INTRODUCTION

Economic development of any Nation depends on stable and relative cheap supply of energy. One of promising sources of energy in the modern world is biomass from which biofuels such as biodiesel, bioethanol, biobutanol etc. are produced. Biofuel sources are abundant and are everywhere in the globe depends on the required fuel to be produced. Harnessing the full potentials of this biomass for the production of biofuels will solve a lot of global challenges such as; environmental degradation, energy crises, unemployment and poverty. Oil rich biomass contains triglycerides which is the require feedstock for the production of biodiesel. Triglycerides are esters of glycerol with three chains of alphatic or olefinic free fatty acid of 12- 24 carbon atoms [1]. Biodiesel is a renewable substitute for fossil diesel but not yet sustainable as its production cost is too high due to limited sources of feedstocks. The use of edible oils feedstocks which were the first generation feedstocks for biodiesel production raised the price of edible oils and biodiesel cost increases [2]. Some of the non-edible oils like *Jatropha curcas,* castor, neem, waste cooking oil, animal fats etc. have been in research for biodiesel production. Yet availability of these feedstocks is not enough for biodiesel to replace a significant part of fossil diesel. In view of this fact, the searches for more non-edible vegetable seed oils continue. Kapok (*Ceiba pentandra)* commonly known as silk cotton tree is a native of Africa found almost every part of Nigeria [3]. It is a fast growing tree and become productive within 4-5 years [3]. The yields increase for about 8 years and its economical lifespan is about 60 years [4]. Its oil is yellow with a pleasant, mild odour and taste having similar characteristic to that of cottonseed oil.

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Kathirvelu *et al* [5] claimed to have produced 93% methyl ester yield from kapok oil by homogenous catalysis using sodium hydroxide catalyst. Endah *et al* [6], got the highest yield of 88.6% biodiesel by heterogeneous catalysis of kapok oil using calcium oxide catalyst. A lot of researches have being carried out with *Jatropha curcas* in biodiesel production but the cost of production and quantity of feedstock available still require more search for local feedstocks not yet explored. Though there are various species silk cotton tree, seeds of unknown specie of the plant from Dutsema Katsina State Nigeria was bought and pressed into oil. In this investigation, transesterification of kapok oil with methanol by varying calcium oxide catalyst loading was carried out to determine the yield of methyl esters.

2 MATERIALS AND METHOD

The materials used in this investigation include; kapok (silk cotton tree) oil, methanol, sulphuric acid, propan-2-ol, calcium oxide catalyst, 250 ml conical flask, magnetic stirrer, thermometer and GC-MS. The kapok (silk cotton tree) oil was esterified from 1.48 to 0.8 acid value by heating 300 g of the oil with 5.0 g methanol and 0.1 g of concentrated sulphuric on a magnetic stirrer for 60 minutes at 60^{o}C. 50 g of the esterified oil was heated to 60^{0}C and a mixture of 12.5 g of methanol and 0.4 g (0.8% w/w of oil) calcium oxide catalyst were added to it. This was transesterified at 60^{o}C for 60 minutes. This same procedure was repeated with 0.6, 0.8, 1.0 and 1.2 g of calcium oxide catalyst. The products of each batch were analyzed with GC-MS machine by dissolving 2 ml of each with n-hexane into sample bottle. The sample bottles were fed into GC-MS machine.

3. RESULTS AND DISCUSSION

The methyl esters yields are quite low compared to that obtained from *Jatropha curcas* seed oil. A highest yield of 78.2% was obtained with kapok oil as against 100% from *Jatropha Curcas* seed oil transesterified with 1.5% same catalyst for 70 minutes at same temperature [7]. The 78.2% yield was achieved with catalyst loading of 0.8 g (1.6% wt. of oil) as shows Figure 1. A lot of methyl esters were produced which could not be listed all in a table. Table 1 shows the methyl esters common to all the five productions.

Table I: Common methyl esters to the five productions

Methyl esters	MF	Catalyst loading				
		0.4g (%)	0.6g (%)	0.8g (%)	1.0g (%)	1.2g (%)
Methyl tridecanoate	$C_{14}H_{28}O_2$	7.55	7.38	7.82	0.084	5.472
Methyl myristate	$C_{15}H_{30}O_2$	0.064	0.174	0.076	0.07	0.154
Methyl -7-hexadecenoate	$C_{17}H_{32}O_2$	0.358	1.65	0.218	1.788	2.006
Methyl 14-methylpentadecanoate	$C_{17}H_{34}O_2$	4.868	4.778	5.04	3.852	5.44
Methyl hexadecanoate	$C_{17}H_{34}O_2$	3.698	3.686	3.872	3.782	5.286
Methyl 15-methylhexadecanoate	$C_{18}H_{36}O_2$	5.39	5.18	5.454	4.342	6.386
Methyl linolelaidate	$C_{19}H_{34}O_2$	4.456	5.058	10.15	1.75	0.636
Methyl 11-octadecenoate	$C_{19}H_{36}O_2$	0.358	0.774	0.58	0.366	0.548
Methyl ricinoleate	$C_{19}H_{36}O_3$	1.578	4.002	4.536	2.844	4.012
Methyl n-octadecanoate	$C_{19}H_{38}O_2$	3.096	2.068	3.276	3.282	4.242
Methyl -11,14-icosadienoate	$C_{21}H_{38}O_2$	5.478	3.3	4.842	0.216	0.318
Methyl eicosanoate	$C_{21}H_{42}O_2$	1.702	1.354	1.332	1.162	2.514
Methyl heneicosanoate	$C_{22}H_{44}O_2$	1.462	1.636	0.746	1.076	2.252
Methyl docosanoate	$C_{23}H_{46}O_2$	3.018	1.652	1.078	2.288	2.932
Methyl -15-tetracosenoate	$C_{25}H_{48}O_2$	0.11	0.546	0.58	4.148	0.548
Methyl tetracosanoate	$C_{25}H_{50}O_2$	0.924	0.4	0.344	0.364	0.426
Hexadecanoic acid, 2,3-dihydroxypropyl ester	$C_{19}H_{38}O_4$	1.7	1.548	1.248	0.75	1.804
Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{19}H_{38}O_4$	0.85	0.774	0.624	0.75	0.902
Pentadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester	$C_{14}H_{36}O_4$	0.85	0.774	0.624	0.75	0.902
9-Octadecenoic acid (Z)-, 2,3-dihydroxypropyl ester	$C_{21}H_{40}O_4$	3.828	3.92	3.056	3.232	1.53
Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester	$C_{35}H_{68}O_5$	0.85	0.774	0.624	0.75	0.902

Despite repeated esterifications the free fatty acids (FFA) of the feedstock still remain high in the products as shows in Figure 2. As high as 14.95 FFA was found in 0.6 g (1.2%) catalyst loading and the least was 7.4% from 2.4% catalyst loading. This FFA value is too high for use in engine to avoid corrosion. To bring down its FFA to a minimum level requires a lot of effort which will translate to high production cost. Alcohols were produced too in high concentration. Alcohol yield ranged from 3.5 to 14. 1% which together with the FFA lowered the yields of methyl esters. Though alcohols may have fuel properties but the bone of contention is methyl esters which is the biodiesel. All the productions had FFA and alcohols.

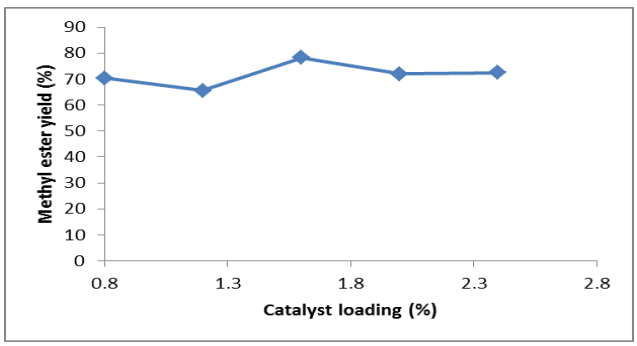

Figure 1: *Methyl esters yield with catalyst loading*

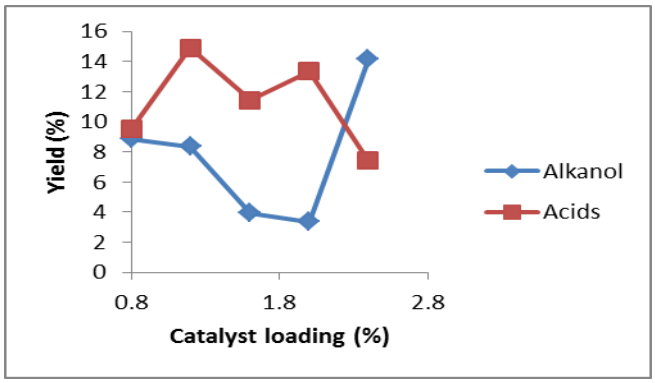

Figure 2: *Alcohols and FFA compositions in the production of the transesterification of kapok oil*

Four of the productions had alkanes, two alkynes and all the five had alkenes. The presence of alkenes and alkynes make the products less stable as these compounds are very reactive radicals. The alkenes content ranged from 2.6 -3.6% of the products as shows in Figure 3. Figure 4 shows the carbonyl compounds and other impurities. Only one of the productions had no carbonyl compound that was the one from 2.4% catalyst loading. The compositions of the carbonyl compounds were low except that of 1.6% catalyst loading that was as high as 4.4%.

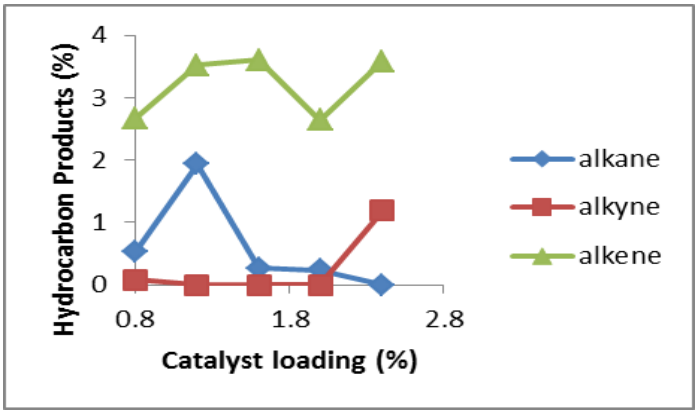

Figure 3: *Hydrocarbons compositions in the products*

4. CONCLUSION

The search for feedstock for the production of biodiesel was extended to kapok oil. The transesterification of kapok oil was carried out with heterogeneous catalyst, CaO. The highest methyl esters yield achieved was 78.2%. Hydrocarbons; alkanes, alkene and alkynes were produced from the reactions. The products had high compositions of free fatty acids and alcohols. Though the FFA of the feedstock was reduced to 0.8 this results indicates that the FFA need to be reduced further for higher methyl ester yield

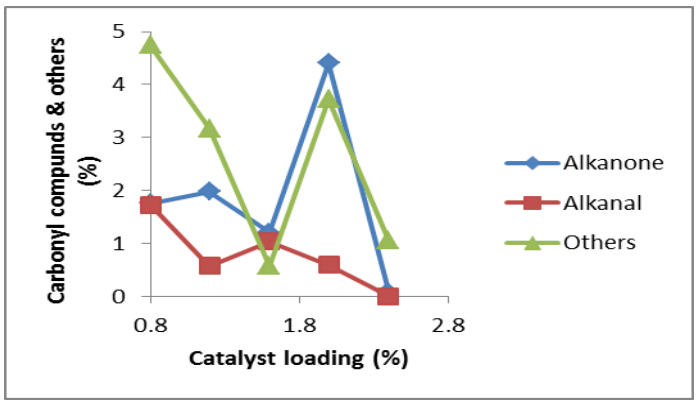

Figure 4: *Carbonyl compositions in the products*

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