Characterization of Biodiesel from Castor Raw Oil

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Abstract

In the present work, castor bio-diesel (C.B.D)fuel of raw castor oil (*Ricinus CommunisL.)* was synthesized in the presence of sodium hydroxide (NaOH) as a catalyst. The influence of catalyst concentration on the yield of castor bio-diesel Fuel was studied. Therefore, different physical properties of bio-diesel could be termed as Caster Bio Diesel (C.B.D) was measured according to American Society of Testing Material (ASTM). Also, the chemical composition of bio diesel was determined by using Gas Chromatography, Mass spectrum (GC-MS) and the functional groups using Infra-Red spectrum (IR). Thus, the main conclusion was drived from both physical and chemical investigations that these synthesized bio-diesel could be used as alternative of diesel.

Keywords: Castor oil, Bio-diesel, GC-Mass spectrometry, IR-spectroscopy.

1. Introduction

Unlike fossil fuels, biodiesel is a renewable source of energy, because it comes from biological sources. On the other hand, fossil fuels come from underground deposits of hydrocarbons which cannot be renewed. Consequently, the significance of bio fuels as an alternative fuel is largely accounted for by its similar power to petrol diesel (High octane number), increased lubricity over petro diesel, compatibility with engine components and most importantly its environmental (reduced emission of green house gases like CO_2, CO) and health benefits; being sulphur, aromatics free and biodegradable **(Okoro L.N.et.al,2011).** Vegetable oils are produced from numerous oil seed crops. Some of these oils have already been evaluated as substitutes for diesel, and gasoline fuels. which include raw sunflower oil**.(Cesarn A.S and Batalha,M.O.,2010)**, blends of raw sunflower, cottonseed, corn, and olive oil with diesel fuel **(Idem R.O et.al,1996)**, cotton seed oil;**(Rakopoulos DC,2011)**;
rapeseed oil **(Sales A,2011)**, jatropha oil**(Maher K.D and Bressler.,2007)**, soybean oil methyl ester (**Rakopoulos DC et al,2014)**,

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catalytic pyrolysis palm oil **(Radwan M.S. et al,2012)**, distilled opium poppy oil and refined rapeseed oil **(Sales A,2011)**, jatropha oil. **(Altin R et al, 2001**),jojoba oil **(Radwan M.S et al., 2012 and Nwafor O, 2000**), castor seed **(Scoll K and sorenson, 1993)** Castor (*Ricinus communis L.*) is a kind of widely cultivated inexpensive, environmentally friendly and industrial oil plant. (**Demirbas A, 2009).**

2. Materials and Methods

2.1 Chemicals

The raw castor oil, Alumina (Al_2O_3), Sodium Carbonate, Potassium Hydroxide, and Sodium hydroxide.

2.2. Synthesizing of Castor Bio-Diesel and Measuring Techniques

The pyrolysis system test bench consists of an oil bath heater, temperature controller, raw oil heating flask, cold water condenser and bio-diesel receiving flask **(Abu-Elyazeed O.S.M, 2015)** such rig was designed and constructed to operate at certain temperature. The physical properties were performed in the labs of Cairo Oil Refining Company Subsidiary of Egyptian General Petroleum Corporation. Such properties were measured according to (ASTM). Also, the chemical compositions were obtained by using both of (GC-MS) and (IR) spectroscopy. The GC-MS were recorded by using Thermo Scientific Analyzer at the Regional Centre for Mycology and Bio technology, Al-Azhar University. The IR spectra were recorded as KBr pellets on a Jasco FTIR plus 460 and Pye Unicam SP-1000 spectro-photometer at the Micro-analytical Unit, Cairo University.

3. Results and Discussion

3.1. Influence of Catalyst Type on the Yield of Castor Biodiesel

It is worth to mention that catalytic conversion of raw castor oil yielded castor biodiesel In addition, the rest of the pyrolyzed raw castor oil was bio-mazot with heaviest and black coloured. This experimental work was carried out at atmospheric pressure and a temperature range of 233 to 400°C with a constant concentration of each catalyst of 1 % by weight. It was noticed that the volumetric yields of yellowish biodiesels as 12%, 27%, 36.1%, 91.7% were gained by using alumina, sodium carbonate, potassium hydroxide and anhydrous sodium hydroxide as catalysts respectively.It was cocluded that by using NaOH as a catalyst the highest total yield of biodiesel 91.7 % was obtianed as illustrated in Figure 1.

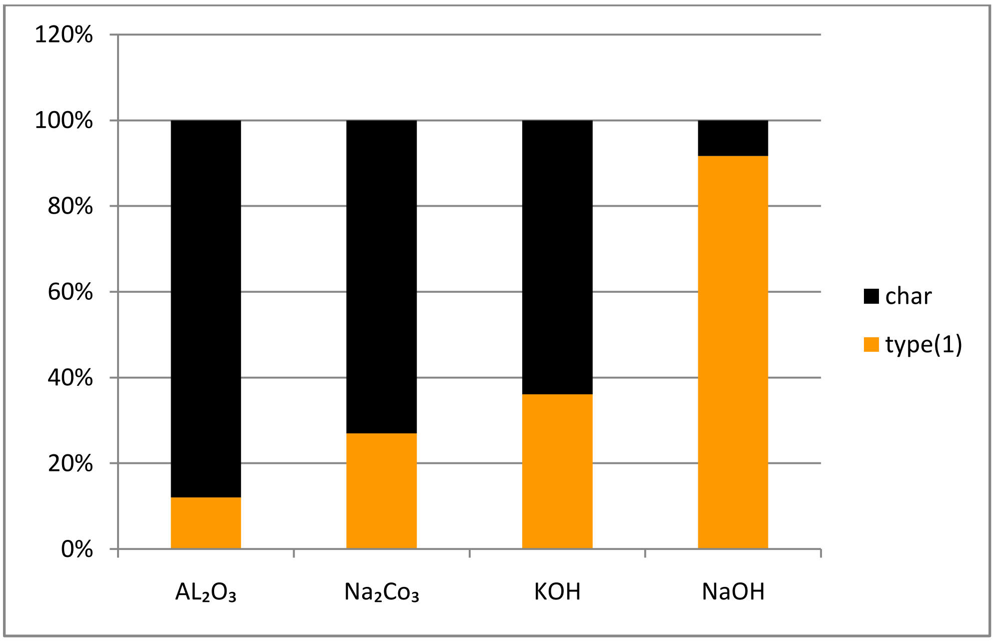

Figure1: Influence of the Catalyst type on the Total Yield of Castor Biodiesel

3.2 Influence of Catalyst Concentration on Total Yield of Castor Biodiesel

The Pyrolysis process in the presence of NaOH as a catalyst due to its high yielding was choosen to show the effect of variation of the concentration of NaOH on the yield . Thus, different concentrations of NaOH was applied at atmospheric pressure and temprature range from 233-347^{o}C as pyrolysis conditions. Figure 2 showed that the highest yeild was gained in the presence of 1% by weight of NaOH. Such yield was decreased by incresing and/or lowering of the catalyst concenteration.

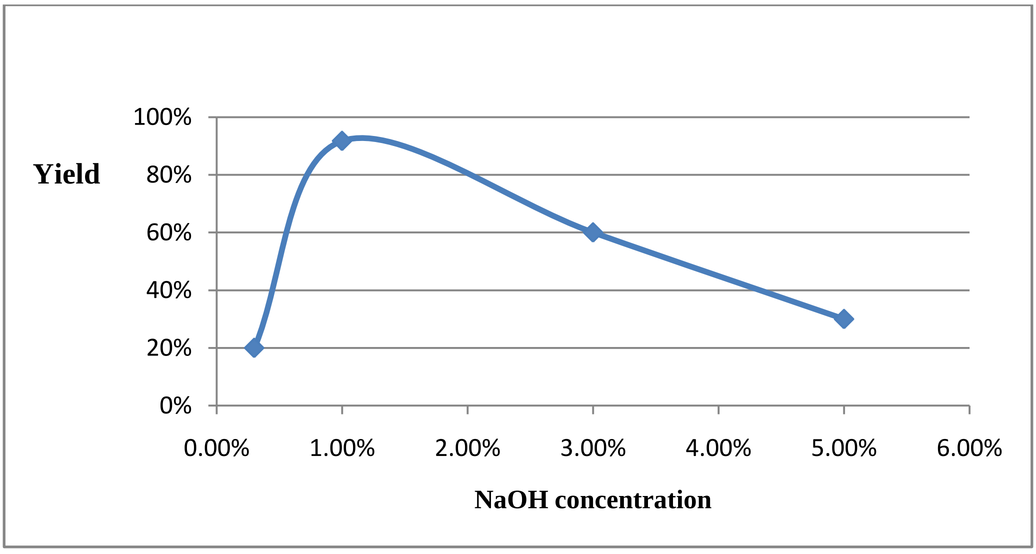

Figure2: Influence of the Catalyst Concentration on the Total Yield of Castor Biodiesel

3.3. Influence of Catalyst Type on Pyrolysis Temperature Range

The temperature range of the pyrolysis procees is considered as one of the most important parameters regarding to energy consumption of this procees. Figure 3 illustrates that the variation of the catalyst types affect strongly on the temperature range of the pyrolysis. Such temperature ranges of 233:347°C, 280:400°C, 254:390°C and 245:370°C were applied in the presence of anhydrous NaOH, Al_2O_3, Na_2Co_3 and KOH as catalysts respectively as shown in Figure 3. Thus it is concloded that the usage of 1% by weight of NaOH as a catalyst not only produce the heighest yeild of castor biodiesels but also achieve the most energy saving regarding the pyrolysis process.

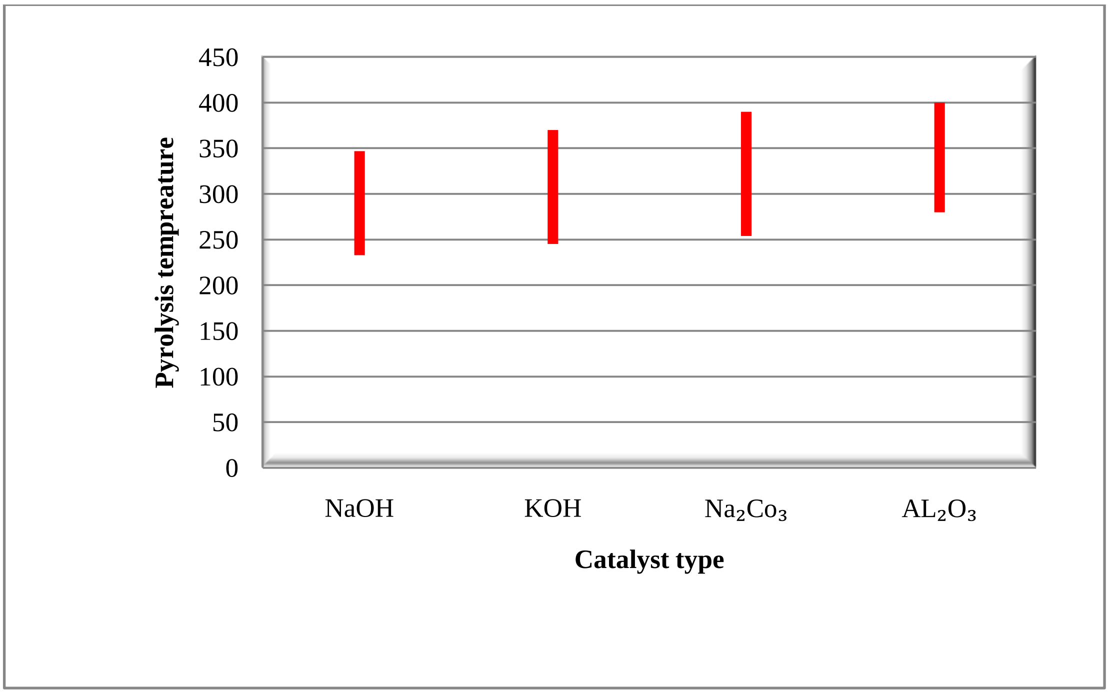

Figure1: Influence of the Catalyst type on Pyrolysis Temperature Range

3.2. Physical Characterization of Different Types of Castor Biodiesel

The physical properties of such raw castor oil are shown in Table 1. The physical propeities of castor biodiesel was measured according to the ASTM standard as shown in Table 2, the values of these physical properites matches with those found in the literature **(Selim et al, 2003)** and diesel standards as well. Table 2 illustrates that the denisty of C.B.D was slightely more than that of diesel standard Thus, could lead to complete physical mixing between commercial fuels and castor bio diesel without separation. The kinematic viscosity of C.B.D was within range of diesel standard as shown in Table 2.

Thus, an expected low droplet size of injected this biodisel (**Rakopoulos DC et al, 2014)**. As shown in Table 2, the flash point of C.B.D is >100°c, which exceed the minimum value of the diesel standards. Furthermore, the pour point of C.B.D was less than the minimum value of the diesel standard. The distillation temperatures of this biodiesel are an indication for the fuel composition, which is normally difficult to obtain for petro diesel, and specifies the maximum temperature of distillation for 85% of its components. The presence of high boiling point components in fuels can significantly affect the degree of formation of solid combustion deposits. Moreover; the sulphur contents are undesirable because of its impact on the formation of toxic compounds. Table 2 showed that the sulfur and ash contents of C.B.D were not detected. As shown in Table 2, the carbon residue of biodiesel was higher than that of diesel standard.. However, the most important property is the cetane number. Table 2 shows that the cetane number of C.B.D was higher than diesel standard. Further more, as shown in Table 2, the cupper Cu-strip corrosion of C.B.D was in agreement with those of diesel standard. Finally, Table 2 shows that the calorefic values of C.B.D was higher than the diesel standard.

Table 1. Physical Properties of Raw Castor Oil

Property	Castor oil
Viscosity (mm^2/s)	239.39
Density at 15 °C (g/cm3)	0.957
Density 20 °C (g/cm3)	0.958
Flash point (°C)	310.0
Sulfur (%)	Nill
Copper strip corrosion	1.0
ASTM color	Yellow

Table 2. Physical Chracteristics of Castor Bio-Diesel versus Diesel Standard

Property	Unit	Diesel Standard	C.B.D	Standard Method
Density at 23°C	Kg/l	0.832	0.8700	ASTM D4052
Specific Gravity		0.85	0.8708	ASTM D1298
Kinematic Viscosity at 40°C		1.6-7	4.347	ASTM D7042
Pensky Flash point Closed cup	°C	Min 55	>100	ASTM D93
Pour point	°C	3:15	-39	ASTM D6749
Disttilation Initial boiling Point 10%distillated by volume 50% distillated by volume 85% distillated by volume 90% distillated by volume Temp of boiling end The rest	°C % volume	Max 85%	68.7 133.2 281.4 - - - 20.0	ASTM 86
SulfurContent	%mass	Max1	0.00	ASTM D4294
Ash	%mass	Max 0.01	0.00	ASTM482
Carbon Residue	%mass	Max 0.1	1.07	ASTM D4530
Cetane Number		Min 46	43.95	ASTM D4737
Cu-strip corrosion at 50°C for 3 hours		Max 1	1	ASTM D130
Calorific value		Min 44.3	45.26	ASTM D4868

3.3. Chemical Characterization of C.B.D via GC-MS Spectrometry

The compounds present in C.B.D were realized by using GC–MS. The results of GC–MS analysis of C.B.D are illustrated in Table3 by considering area percentage, the highest peak areas of total ion chromatogram (TIC) of compounds are ethyl ether; hexane-3-methyl; n-nonane; n-heptaldehyde; heptoic acid;1b,5,5,6a-tetramethyloctahydro-6H-indeno[1,2-b]oxiren-6-one;1-(2`-nitro-2`propenyl)-cyclo hexene; myristyl chloride; 1-chlorooctadecane; oleic acid; 11-cyclopentylundecanoic acid; preg-4-en-3-one,17à-hydroxy-17á-cyano; 10-undecenoic acid ;oxacyclotetradeca-4,11-diyne; 1,3,5 triazine-2,4 diamine -6- chloro n-ethyle; iso chiapin B . The presence of nitrogen compounds and appearance of halogens is attributed to the composition of castor seeds which derives these elements from the soil. The results of castor pyrolysis oil analysed by GC-MS reveal that compounds present are matched with other bio oils given in literature (**Singh R.K and Shadangik., 2011).**

Table3.GC-Mass Spectrometry Analysis of C.B.D

RT	Compound Name	Area%	Molecular Formula	Molecular Weight
3.29	Ethyl ether.	17.74	$C_4H_{10}O$	74
3.40	Hexane-3-methyl	4.96	C_7H_{16}	100
5.33	N-Nonane	6.50	C_9H_{20}	128
5.80	N-Heptaldehyde.	24.07	$C_7H_{14}O$	114
8.46	Heptoic acid.	3.35	$C_7H_{14}O_2$	130
8.81	1b,5,5,6a-Tetramethyloctahydro-6H-indeno[1,2-b]oxiren-6-one	0.46	$C_{13}H_{20}O_2$	208
9.35	1-(2`-Nitro-2`propenyl)-cyclo hexene.	0.59	$C_9H_{13}NO_2$	167
9.57	Myristyl chloride	5.73	$C_{14}H_{21}Cl$	170
10.95	1-Chlorooctadecane	5.34	$C_{18}H_{37}Cl$	288
11.06	Oleic acid.	2.54	$C_{18}H_{34}O_2$	282
12.29	11-Cyclopentylundecanoic acid.	2.39	$C_{16}H_{30}O_2$	254
12.65	Preg-4-en-3-one, 17à-hydroxy-17á-cyano	0.13	$C_{20}H_{27}NO_2$	313
13.64	10-Undecenoic acid.	6.85	$C_{11}H_{20}O_2$	184
13.83	Oxacyclotetradeca-4,11-diyne	0.24	$C_{13}H_{18}O$	190
15.92	1,3,5 Triazine-2,4 diamine -6-chloro n-ethyle.	0.51	$C_5H_8ClN_5$	173
24.80	IsochiapinB.	0.32	$C_{19}H_{26}O_6$	346

3.4. Chemical Characterization of C.B.D by IR Spectroscopy

The IR spectra of the castor bio diesels showed the functional groups similar to that found in the literature **(Scoll K and Sorenson ,1993 ; Demirbas A ,2009Error! Bookmark not defined.; Liu S,2015)** which makes it as a good alternative to the traditional fuel. The IR spectra of C.B.D (Table 4) showed an OH group at 3424 cm^{-1}; = CH stretch of aromatics at 3073 cm^{-1}; CH aliphatics at 2926 cm^{-1} and 2857 cm^{-1}. Additionally, the spectra revealed carbonyl group at 1710 cm^{-1};C=C at 1645 and 1459 cm^{-1}; and aromatic hydrocarbon carbons at 1459 and 1415 cm^{-1}; C-O stretch of ether at 1051 cm^{-1}.

Table 4. Functional Groups of IR Spectroscopy of C.B.D

Functional Group	Wave Number (cm^{-1})
O–H stretching	3424.96
=CH stretch of aromatics	3073
CH aliphatic	2926.45 and2857.96
C=O carbonyl group	1710.55
C=C	1645.38
C-C stretching	1459.85 and 1415.49
C-O stretch of ether	1051.01
Opp CH bending	725.104

4. Conclusion

The different chemical and physical properties of castor bio-diesel were measured and the resulted bio-diesel appears to be potentially useful for power production, since its calorific value similar to petroleum fuels used commercially. Thus, this bio diesel can be used directly in industrial burning equipped to handle these types of fuels or used as a blend to improve fuel quality.

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الملخص العربي

توصيف الوقود الحيو ي من الخروع الخام

محمد صالح عبد الفتاح[ا] ،اسيد سيد محمد ابو اليزيد[ب]،ابتسام عبد المولي[ا] و مروة احمد عبد العظيم[ا] .

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علي خلاف الوقود الحفرى فالوقود الحيوي يعتبر مصدر متجدد للطاقه، وذلك لان الحصول عليه يتم من المصادر البيولوجيه. علي الصعيد الاخر الوقود الحفري مصدره الترسيبات الارضيه للهيدروكربونات وهي غير متجدده وبناء علي ذلك فان التركيز علي الوقود الحيوي كبديل للوقود الحفري راجع لكون الطاقه الحراريه الناتجه عنه مماثله لتلك الناتجه عن الوقود الحفري ،كماانها متوائمه مع مكونات المحرك والاكثر اهميه من ذلك انها تحافظ علي البيئه من حيث تقليل انبعاثات ثاني اكسيد الكربون واول اكسيد الكربون وفوائده للصحه العامه كونه خالي من الكبريت والمركبات الاروماتيه الي جانب انه قابل للتحلل.

الزيوت النباتيه تنتج من عدد هائل من بذور الحبوب وبعض منها استخدم كبديل لزيوت للديزل والبنزين وتضم زيت عباد الشمس الخام، اضافات من زيت عباد الشمس وزيت بذرة القطن وزيت الزيتون مع الديزل ، زيت بذره القطن، زيت اللفت الخام، استرات فول الصويا، زيت النخيل المتحلل حراريا، زيت نفط الخشخاش المقطر، زيت الجتروفا، زيت الجوجوبا وزيت بذور الخروع وبالنسبه الي الخروع محل الدراسه فهو نبات زيتي واسع الانتشار ،غير مكلف كماانه صديق للبيئه.

ومن خلال هذه الدراسه تم تخليق الوقود الحيوي من زيت الخروع الخام في وجود عامل حفاز (هيدروكسيد الصوديوم) ولقد تم حساب كميه الوقود الناتج في وجود تركيزات مختلفه من العامل الحفاز بناء علي مقارنه الكميات الناتجه تم تحديد افضل تركيز للعامل الحفاز للحصول علي اعلي كميه من الوقود كما تم توصيف الوقود الناتج من الخروع بعد قياس الخواص الكيميائيه الي جانب قياس الخواص الفيزيائيه المختلفه باستخدام جهاز الكروماتوجرام والتحليل الطيفي بالاشعه فوق الحمراء. النتائج التي تم الحصول عليها اوضحت ان القيمة الحراريه للوقود الناتج تتيح استخدامه كمصدر للطاقه وكبديل للوقود الحفري ، ويمكن استخدامه في محركات الاحتراق الداخلي وغرف احتراق المحركات والتوربينات والغلايات.