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PLANNING AND EVALUATION OF CATALYTIC CRACKING PRODUCTS OF NON-PALATABLE VEGETABLE OILS USING ACIDIC CATALYSTS

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ABSTRACT

Jatropha and Castor oils were acquired and changed into their relating biodiesels by reactant breaking utilizing heterogeneous catalysts (Alumina and Montmorillonite-Hcl) with various proportions (0.2%, 0.4%, 0.6%, 0.8% and 1%). The particulars of the acquired items were similar to American Society for Testing and Materials (ASTM) details. The details of the got biodiesel were equivalent to fuel properties of petrol diesel. The appropriate mix between the got biodiesel and fuel was portrayed.

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INTRODUCTION

Petrol assumes a significant part in our life. Energizes, ointments, wellsprings of warmth and force age, and crude materials in the petrochemical ventures are gotten from petrol. It is realized that oil is a nonrenewable wellspring of energy, thus it will vanish in one day of our future, so it is important to discover different wellsprings of energy to proceed with our existence effortlessly. Researchers are presently looking for new sources to supplant oil. Biofuels are proposed to be the most secure powers to climate that can be utilized. As well as having lower life cycle greenhouse gas (GHG) discharges, economical biofuels ought not contend with food or new water assets or add to deforestation. Oil-based energy crops that can meet these maintainability rules incorporate jatropha and castor oil. The decision of jatropha seed oil is great as it is non-eatable oil, so there will be no contest with food crops. The biodiesel is portrayed by deciding its physical and fuel properties including thickness, consistency, iodine esteem, corrosive worth, cloud point, pour point and unpredictability as per ASTM norms. Biodiesel is best than petrol diesel because of a few qualities including: simplicity of transport, inexhaustible, powerful in burning interaction, low fragrant and sulfur content, high cetane number [Balat, 2008], and biodegradable [Demirbas, 2009]. Biodiesel has higher boundaries contrasted with petrol diesel including: thickness, cloud point, pour point, nitrogen oxide emanation, and motor wear; and lower boundaries, for example, energy content, motor speed, and motor similarity [Demirbas, 2008]. As to wellbeing perspective, biodiesel has security benefits than oil diesel, as it is lower burnable and higher blaze point [Onukwuli *et al.,* 2017]. These biodiesels can be blended in with oil diesel in any extent or straightforwardly utilized in diesel motor without alteration [Gunawan, 2011].The significant expense of biodiesel is the significant hindrance to its commercialization [Demirbas, 2009], and 80 % of the complete expense of biodiesel creation is the expense of the crude materials [Wang, 2011]. Biofuels are gotten by breaking of various vegetable oils including: Alcea pale oil [Aysu, 2011], woody oils [Xu, 2010], soybean oil [Yu, 2013], palm oil [Sang, 2003], cotton seeds oil [Li, 2009], Jatropha oil [Biswas, 2014], and squander cooking oils [Tang, 2007]. Breaking of vegetable oils performed either thermally without utilizing any sort of impetus [Da Mota, 2014], or by utilizing basic impetuses [Babich, 2011], metal oxides [Yigezu, 2014], zeolite [Zhang, 2009; Li, 2014; Doronin, 2012]. Attributable to financial reasons, the utilization of minimal expense crude material, for example, Egyptian castor oil (ECO) planted in Upper Egypt in Al-Alaki valley and inundated utilizing modern and pretreated wastewater, is being considered for biodiesel creation. Castor oil is planted in Upper Egypt and is generally dispersed in the southern and southwestern locales with an all-out space of around 2,000,000 ha, and the yearly seeds creation is over 250,700 tons [Christopher Brickell, 1996]. The yield of the castor oilseed is around 40-60 %. What's more, the castor trees are acquiring significance because of its low support and less yield cultivation the executives rehearses required [Christopher Brickell, 1996]. This paper planned to assess the biodiesel that is created from reactant breaking of Egyptian castor and jatropha oils utilizing ASTM principles, and contrast its fuel properties and petrol diesel.

MATERIALS AND METHODS

Materials

Jatropha and Castor oils were removed from Jatropha and Castor seeds through water driven squeezing; Alumina and Montmorillonite-Hcl catalysts were bought from (Sigma-Aldrich, Germany).

Methods

Extraction of Jatropha and Castor oils

Dry Jatropha and Castor seeds (500 g) were squashed separately utilizing a water powered press until the oil was extricated. The oil was centrifuged to eliminate any strong pollutants and water, and utilized minus any additional decontamination or treatment.

Catalytic cracking of Jatrophaand Castor oilinto biodiesel: Reactant breaking strategies were proceeded as follows: 150 mL of Jatropha and Castor oils were charged separately in 500 mL two necked carafe and (Alumina and Montmorillonite-Hcl) catalysts were added exclusively at various proportions of (0.2%, 0.4%, 0.6%, 0.8% and 1%) by weight comparative with oil. The combination was blended and permitted to warm fomentation for 4 hrs at 250 ^{o}C. The response items were gathered by a condenser and their volumes were resolved. The got biofuels from the two oils were gotten comfortable an isolating channel to isolate the delivered water and afterward centrifuged to eliminate any sullied or scattered water. The response was finished and the items were: 75% biofuel, 15% water, 3% solids, and the rest were vapors.There are a few boundaries which influence the change response of Jatropha and Castor oils into biodiesels including: the impetus proportion (%), transformation time and temperature.These boundaries were concentrated to achieve the enhanced transformation response conditions.

Oil characterization: The unsaturated fat structure of the acquired Jatropha and Castor oils was resolved utilizing GC-Chromatographic investigation utilizing GC-7890A instrument outfitted with DB-23 segment, 60 mm x 0.25 mm, i.d. of 0.25 µm. The trademark properties of Jatropha and Castor oils were resolved including the accompanying: iodine value, acid value, kinematic viscosity at 40°C, density, cloud point, pour point, oxidation stabilityand sulphur content.

Biofuel specification: The trademark particulars of the acquired biofuels, for example, kinematic viscosity at 40°C, cetane number, density, pour point, cloud point, flash point, carbon residue and ash content were additionally decided by ASTM specifications [22-30]. The appropriate mix between the acquired biodiesel and fuel was portrayed.

RESULTS AND DISCUSSION

The characteristic properties of Jatropha and Castor oils: The fatty acid profileand the properties of Jatropha and Castor oilswere listed in *Table 1*.

Table 1.The fatty acid profileand properties of Jatropha and Castor oils

Property	Castor oil	Jatropha oil
Fatty acid composition (wt %):		
Myristic acid (C14:0)	-----	2.00
Palmitic acid (C16:0)	2.00	15.00
Palmitoleic acid (C16:1)	-----	0.70
Stearic acid (C18:0)	-----	6.50
Oleic acid (C18:1)	3.00	43.60
Linoleic acid (C18:2)	5.00	32.00
Linolenic acid (C18:3)	1.00	-----
Arachidic acid (C20:0)	-----	0.20
Ricinoleic acid (C18:1, OH)	89.00	-----
Acid value, (mg KOH/g)	3.0	3.80
Kinematic Viscosity @ 40 °C, (mm^2/s)	43.0	37.0
Density, (kg/m^3) at 15 °C	0.959	0.910
Cloud point, (°C)	8	6
Pour point, (°C)	4	2
Oxidation stability, (h)	5.5	2.56
Iodine value, gI$_2$/100 g oil	80.5	104.46
Sulphur content %	0.08	0.02

Table 2. The properties of the biofuel obtained from the studied Jatropha and Castor oils

Biofuel Property	Castor oil	Jatropha oil
Cetane number	54	55
Kinematic Viscosity @ 40°C, (mm^2/s)	3.64	3.66
Density, (g/cm^3) at 15 °C	0.864	0.859
Cloud point, (°C)	3	3
Pour point, (°C)	-9	-9
Flash point, (°C)	150	161
Iodine value, gI$_2$/100 g oil	82.5	105.5
Carbon residue %	0.07	0.08
Ash %	Nil	Nil

Table 3.Physical & Chemical Properties of Biofuel* B10 (10% Biodiesel + 90% Gas Oil) *Biofuel: JatrophaOil with Alumina Catalyst (0.2, 0.4, 0.6, 0.8, 1 % conc.)

Property	Biofuel* B10 (10% Biodiesel + 90% Gas Oil)					Gas Oil	Specification Limits	Test Method
	0.2%	0.4%	0.6%	0.8%	1%			
Density @ 15 ^{O}C gm/cm^{3}	0.8462	0.8463	0.8463	0.8468	0.8472	0.8394	Reported	ASTM D-4052
Flash point (P.M.C.C) ^{O}C	59	61	55	58	59	71	52 (min.)	ASTM D-93
Pour point ^{O}C	-6	-6	-9	-6	-6	-9	15 (max.)	ASTM D-97
Cloud point ^{O}C	3	3	3	3	3	3	-3 to 12	ASTM D-2500
Kinematic viscosity at 40 ^{O}C CSt	3.07	3.11	3.11	3.12	3.12	3.13	1.6-7	ASTM D-445
Recovery @ 350 ^{O}C ml	92	91	92	92	92	91	85 (min.)	ASTM D-86
Water and Sediment %vol	Nil	Nil	Nil	Nil	Nil	Nil	0.1 (max.)	ASTM D-2709
Total Sulphur %wt	0.036	0.038	0.037	0.036	0.040	0.047	1 (max.)	ASTM D-4294
Copper corrosion strip @ 50^{O}C/3h	1	1	1	1	1	1	1 (max.)	ASTM D-130
Carbon Residue %wt	0.08	0.06	0.07	0.08	0.06	0.07	0.1 (max.)	ASTM D-4530
Ash content %wt	Nil	Nil	Nil	Nil	Nil	Nil	0.01 (max.)	ASTM D-482
Color	2	2	2	2	2	2	4 (max.)	ASTM D-6045
Cetane index	51	50	50	51	51	49.3	40 (min.)	ASTM D-4737

Table 4. Physical & Chemical Properties of Biofuel* B10 (10% Biodiesel + 90% Gas Oil) *Biofuel: Castor Oil with Alumina Catalyst (0.2, 0.4, 0.6, 0.8, 1 % conc.)

Property	Biofuel* B10 (10% Biodiesel + 90% Gas Oil)					Gas Oil	Specification Limits	Test Method
	0.2%	0.4%	0.6%	0.8%	1%			
Density @ 15 ^{O}C gm/cm^{3}	0.8471	0.8471	0.8472	0.8471	0.8472	0.8394	Reported	ASTM D-4052
Flash point (P.M.C.C) ^{O}C	61	60	58	59	59	71	52 (min.)	ASTM D-93
Pour point ^{O}C	-9	-6	-6	-6	-9	-9	15 (max.)	ASTM D-97
Cloud point ^{O}C	3	3	3	3	3	3	-3 to 12	ASTM D-2500
Kinematic viscosity at 40 ^{O}C CSt	3.11	3.09	3.12	3.13	3.13	3.13	1.6-7	ASTM D-445
Recovery @ 350 ^{O}C ml	91	90	92	91	92	91	85 (min.)	ASTM D-86
Water and Sediment %vol	Nil	Nil	Nil	Nil	Nil	Nil	0.1 (max.)	ASTM D-2709
Total Sulphur %wt	0.040	0.041	0.039	0.038	0.041	0.047	1 (max.)	ASTM D-4294
Copper corrosion strip @ 50^{O}C/3h	1	1	1	1	1	1	1 (max.)	ASTM D-130
Carbon Residue %wt	0.07	0.06	0.06	0.08	0.08	0.07	0.1 (max.)	ASTM D-4530
Ash content %wt	Nil	Nil	Nil	Nil	Nil	Nil	0.01 (max.)	ASTM D-482
Color	2	2	2	2	2	2	4 (max.)	ASTM D-6045
Cetane index	49	50	51	50	51	49.3	40 (min.)	ASTM D-4737

Properties of the obtained biofuel: The chromatographic charts of the Jatropha and Castor oils; and the obtained biofuels were represented in Figure 1. It is clear from the values of the retention time of oils that Castor oil fractions have higher retention times at 7, 16, 23, 26, 29 and 40 min corresponding to palmitic, stearic, oleic, linoleic and ricinoleic acids. Also, their intensities are comparable to their abundance in the Castor oil. Additionally, Jatropha oil fractions located in the chromatographic chart at low retention times of 4, 9, 14, 24 and 29 min corresponding to myristic, palmitic, stearic, oleic and linoleic acids at comparable intensities to their abundance in the Jatropha oil. The physical properties of the obtained biofuel were determined and compared to ASTM limits specifications. The measured characteristics were: kinematic viscosity at 40°C, iodine value, density, cetane number, pour point, cloud point, ash content, carbon residue and flash point were listed in Table 2.

The suitable blend between the obtained biofuel and gas oil fuel: In this examination, numerous mixes were made between the pre-arranged biofueland gas oil fuel. The appropriate mix between the acquired biofuel and gas oil fuel was (10% Biodiesel + 90% Gas Oil). The consequences of this biodiesel mix were in satisfactory reach contrasted with gas oil fuel as per the standard upsides of ASTM specifications***Tables3-6***. The flash point of the got biofuel decreases than ASTM particulars (under 52 °C), when the mixing proportion of the pre-arranged biodiesel to oil diesel increments than 10%.

Table 5.Physical & Chemical Properties of Biofuel* B10 (10% Biodiesel + 90% Gas Oil) *Biofuel: Jatropha Oil with Montmorillonite-HCL Catalyst (0.2, 0.4, 0.6, 0.8, 1 % conc.)

Property	Biofuel* B10 (10% Biodiesel + 90% Gas Oil)					Gas Oil	Specification Limits	Test Method
	0.2%	0.4%	0.6%	0.8%	1%			
Density @ 15 ^{O}C gm/cm^3	0.8466	0.8462	0.8465	0.8471	0.8472	0.8394	Reported	ASTM D-4052
Flash point (P.M.C.C) ^{O}C	60	61	62	59	60	71	52 (min.)	ASTM D-93
Pour point ^{O}C	-6	-9	-6	-6	-6	-9	15 (max.)	ASTM D-97
Cloud point ^{O}C	3	3	3	3	3	3	-3 to 12	ASTM D-2500
Kinematic viscosity at 40 ^{O}C CSt	3.10	3.13	3.11	3.13	3.12	3.13	1.6-7	ASTM D-445
Recovery @ 350 ^{O}C ml	90	9	92	90	90	91	85 (min.)	ASTM D-86
Water and Sediment %vol	Nil	Nil	Nil	Nil	Nil	Nil	0.1 (max.)	ASTM D-2709
Total Sulphur %wt	0.039	0.042	0.043	0.038	0.041	0.047	1 (max.)	ASTM D-4294
Copper corrosion strip @ 50^{O}C/3h	1	1	1	1	1	1	1 (max.)	ASTM D-130
Carbon Residue %wt	0.07	0.07	0.07	0.08	0.07	0.07	0.1 (max.)	ASTM D-4530
Ash content %wt	Nil	Nil	Nil	Nil	Nil	Nil	0.01 (max.)	ASTM D-482
Color	2	2	2	2	2	2	4 (max.)	ASTM D-6045
Cetane index	50	50	50	51	50	49.3	40 (min.)	ASTM D-4737

Table 6.Physical & Chemical Properties of Biofuel* B10 (10% Biodiesel + 90% Gas Oil) *Biofuel: Castor Oil with Montmorillonite-HCL Catalyst (0.2, 0.4, 0.6, 0.8, 1 % conc.)

Property	Biofuel* B10 (10% Biodiesel + 90% Gas Oil)					Gas Oil	Specification Limits	Test Method
	0.2%	0.4%	0.6%	0.8%	1%			
Density @ 15 ^{O}C gm/cm^3	0.8465	0.8464	0.8468	0.8468	0.8470	0.8394	Reported	ASTM D-4052
Flash point (P.M.C.C) ^{O}C	60	60	60	58	59	71	52 (min.)	ASTM D-93
Pour point ^{O}C	-9	-6	-6	-9	-6	-9	15 (max.)	ASTM D-97
Cloud point ^{O}C	3	3	3	3	3	3	-3 to 12	ASTM D-2500
Kinematic viscosity at 40 ^{O}C CSt	3.08	3.09	3.12	3.11	3.12	3.13	1.6-7	ASTM D-445
Recovery @ 350 ^{O}C ml	91	91	92	90	92	91	85 (min.)	ASTM D-86
Water and Sediment %vol	Nil	Nil	Nil	Nil	Nil	Nil	0.1 (max.)	ASTM D-2709
Total Sulphur %wt	0.038	0.038	0.038	0.036	0.039	0.047	1 (max.)	ASTM D-4294
Copper corrosion strip @ 50^{O}C/3h	1	1	1	1	1	1	1 (max.)	ASTM D-130
Carbon Residue %wt	0.07	0.06	0.08	0.08	0.07	0.07	0.1 (max.)	ASTM D-4530
Ash content %wt	Nil	Nil	Nil	Nil	Nil	Nil	0.01 (max.)	ASTM D-482
Color	2	2	2	2	2	2	4 (max.)	ASTM D-6045
Cetane index	49	49	50	50	51	49.3	40 (min.)	ASTM D-4737

Kinematic Viscosity at 40 ^{o}C: Kinematic viscosity represents the flow characteristics and the tendency of fluids to deform with stress. Kinematicviscosity is expressed in centistokes (cSt). For gas oil, the kinematic viscosity at 40^{o}C should be between (1.6 cSt –7.0 cSt) in ASTM D-445 [24]. The obtained kinematicviscosity values of the prepared biodiesel blends were within the range of ASTM (3.07 cSt – 3.13cSt).

Cetane Number: The cetane number (CN) defines as the ability of fuel to ignite quickly after being injected. Higher value of (CN) indicates better ignition quality of fuel. For gas oil, the cetane number should be (min. 40)inASTM D-4737[29].The obtained cetane number values of the prepared biodiesel blend were within the range of ASTM (49 – 51). The higher value of cetane number of the produced biodiesel from Jatropha and Castor oilsrepresents its high ability towards ignition in engines after injection.

Density: The density of the fuel represents the weight of one gram of it. The density is an important factor during the fuel processing and ignition, because the fuel represents an extra weight on the vesicle. Consequently, higher density of fuel will consume larger amount of fuel during the automotive work. For gas oil, the density value was (0.8394 g/cm^3)according to ASTM D-4052 [27]. The obtained density values of the prepared biodiesel blends were within the range of (0.8462–0.8472 g/cm^3), which is comparably slightly higher than the density of gas oil.

Pour Point: The pour point of the fuel represents the temperature at which the fuel becomes solid before it and liquid after it. Pour point is important characteristic during the transportation of the fuel at elevated low temperatures. In cold climate countries of low temperatures, high pour point fuels freeze.

The pour point measurement is a standard test which applied to measure the flow properties of biodiesel during operating in cold weathers [33].For gas oil, the pour point should be (max. 15 ^{o}C)inASTM D-97 [23].The obtained pour point values of the prepared biodiesel blends were within the range of ASTM (-6^{o}C to -9 ^{o}C).

Cloud Point: The cloud point is defined as the temperature at which a cloud of wax crystals first appears in a liquid when it is cooled. In general, wax crystals occur in two phases: nucleation and growth of crystals. The cloud point of biodiesel occurs during the start of wax cluster formation involving higher molecular weight components to give visible crystals [32-34]. By continuous cooling of the sample, the agglomeration occurs. At this point, it involves the interaction between the high and low melting components to give bigger crystals. Low cloud points of the biofuels are important property due to the formation of regular clusters of the hydrocarbons lowers the fluidity of the biofuel which decreases its transportation through pipes and tubes. For gas oil, the cloud point should be (-3^{o}C to 12 ^{o}C) in ASTM D-2500 [26].The obtained cloud point values of the prepared biodiesel blends were within the range of ASTM (3^{o}C).

Flash Point: The flash point is the temperature at which the fuel becomes a mixture that will ignite when exposed to a spark or flame. Since biodiesel has high flash point, it is a safer fuel to transport and handle[31]. For gas oil, the flash point should be (min. 52^{o}C)inASTM D-93.The obtained flash point values of the prepared biodiesel blends were within the range of ASTM (55 ^{o}C – 62 ^{o}C).

Carbon Residue: For gas oil, the carbon percentage should be (max. 0.1 %)inASTM D-4530 [28].The obtained carbon percentage values of the prepared biodiesel blends were within the range of ASTM (0.06 % – 0.08%), which are very low values and did not cause any potential on the environment when ignited.

Ash Content: For gas oil, the ash percentage should be (max. 0.01 %)inASTM D-482 [25].The obtained ash percentage values of the prepared biodiesel blends were within the range of ASTM (Nil), which did not cause any potential on the environment when ignited.

Conclusions

From the results obtained in this study, the following conclusions can be recorded:

- Jatropha and Castor oilswere converted into biofuel using heterogeneous catalysts (Alumina andMontmorillonite-Hcl) with different ratios (0.2%, 0.4%, 0.6%, 0.8% & 1%).
- The specifications of the obtained products were comparable to ASTM specifications.
- The suitable blend between the obtained biofuel and gas oil fuel was (10% Biodiesel + 90% Gas Oil).
- The results of this biodiesel blend were in acceptable range compared to gas oil fuel according to the standard values of ASTM specifications.
- When the blending ratio of the prepared biodiesel to petroleum diesel increases than 10%, the flash point of the obtained biofuel decreases than ASTM specifications(less than 52 ^{o}C).

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