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Quality improvement of Sudanese gasoline by using Di isopropyl ether and Moringa oil

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Abstract:

The main objective of this project blending of Di isopropyl ether and Moringa oil with Sudanese gasoline, which intent of enhancing octane number to reformat gasoline was product from Khartoum refinery. Reformat gasoline was tested by ASTM standard methods, such as Distillation temperatures, Sulfur content, density, vapor pressure, oxidation stability , cupper corrosion , Gum existent, lead content, and octane number measuring by CFR. Reformat gasoline MON was recorded (88.5). Di isopropyl ether and Moringa oil were added to the reformat gasoline. Octane number of blends was measured by CFR engine .additives were add in (5, 10%vol) to reformat gasoline, increasing MON was (2.1-6.5).

Key words: quality of gasoline, octane number, Moringa oil, Di isopropyl ether.

1. Introduction

Gasoline, also spelled gasoline, also called gas or petrol, mixture of volatile, flammable liquid hydrocarbons derived from petroleum and used as fuel for internal-combustion engines. It

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is also used as a solvent for oils and fats , originally a by-product of the petroleum industry (kerosene being the principal product), gasoline became the preferred automobile fuel because of its high energy of combustion and capacity to mix readily with air in a carburetor, gasoline was at first produced by distillation, simply separating the volatile, more valuable fractions of crude petroleum . Later processes, designed to raise the yield of gasoline from crude oil, split large molecules into smaller ones by processes known as cracking (Ali. E., 2006). Thermal cracking, employing heat and high pressures, was introduced in 1913 but was replaced after 1937 by catalytic cracking, the application of catalysts that facilitate chemical reactions producing more gasoline, other methods used to improve the quality of gasoline and increase its supply include polymerization, converting gaseous olefins, such as propylene and butylene, into larger molecules in the gasoline range; alkylation, a process combining an olefin and a paraffin such as isobutene; isomerization, the conversion of straight-chain hydrocarbons to branched-chain hydrocarbons; and reforming, using either heat or a catalyst to rearrange the molecular structure (Perdiha, A., 2006). Gasoline is a complex mixture of hundreds of different hydrocarbons. Most are saturated and contain 4 to 12 carbon atoms per molecule. Gasoline used in automobiles boils mainly between 30° and 200° C (85° and 390° F), the blend being adjusted to altitude and season. Aviation gasoline contains smaller proportions of both the less-volatile and more-volatile components than automobile gasoline (Ghosh, P., 2006). The antiknock characteristics of a gasoline—its ability to resist knocking, which indicates that the combustion of fuel vapor in the cylinder is taking place too rapidly for efficiency—is expressed in octane number. The addition of tetra ethyl lead to retard the combustion was initiated in the 1930s but was discontinued in the 1980s because of the toxicity of the lead compounds discharged in the combustion products, other additives to gasoline often include detergents to reduce the buildup of engine deposits, anti-icing agents to prevent stalling caused by carburetor icing, and antioxidants (oxidation inhibitors) used to reduce “gum” formation. In the late 20th century the rising price of petroleum (and hence of gasoline) in many countries led to the increasing use of gasohol, which is a mixture of 90 percent un leaded gasoline and 10 percent ethanol (ethyl alcohol). Gasohol burns well in gasoline engines and is a desirable alternative fuel for certain applications because of the renew ability of ethanol, which can be produced from grains, potatoes, and certain other plant matter. Octane number (ON) is one of the most important properties of gasoline streams and is a measure of its antiknock property. It is defined as the volume percentage of *i*-octane in a blend of *n*-heptane and *i*-octane, which produces the same knock intensity as the test fuel under standard test conditions in an ASTM internal combustion engine. ASTM defines two different types of ONs, the research octane number (RON) and the motor octane number (MON), which are evaluated using the ASTM D2699and the ASTM D2700 tests, respectively 1, 2. Both methods use the same standard test engine but differ in the operating conditions. RON is measured in an engine running at 600 rpm and a fuel/air mixture at a temperature of 60° F, while MON is measured with the engine running at 900 rpm and a fuel/air mixture at a temperature of 300° F (Seddon. D., 2000). The slower engine speed and the lower fuel/air temperature as required in the RON test are representative of the fuel performance for city driving, while the faster engine speeds and higher fuel/air temperature represent the fuel performance for highway driving, the development of petroleum products has gained a global importance in supporting economical status, one of petroleum crucial products in the gasoline. The most important clue to improve this product, is the raising of its octane number which represent a basic parameter in expressing the quality of gasoline by using alternative materials other than tetra ethyl lead which is hazardous to the environment to both plants and animals (Ali .H. A., 2007).

The benefit of raising the octane number is to reduce the knocking and regales the movement of pistons inside the combustion cylinders which render the combustion process complete and moderate. Cones quality this reduce the quantities of gases diffused in to the environment like nitrogen dioxide. Also the reduction of fuel consumption and the increment in the car engine lifetime is a well known fact that high, performance vehicles need high quality gasoline, hence Khartoum refinery used the isomerisation, alkylation, polymerization and catalytic cracking. The treatment of gasoline taken place via thermal and hydrogen cracking to raise the octane number to 91 as an upper limit. This vehicle needs (ON=93) gasoline for the duration of their engine and this can be a chivied only upon external addition (Hamdan. M. A., 2001).

2. Experimental Work

2.1. Gasoline specification

Gasoline it usually defined by government regulation, where properties and test methods are clearly defined. In the US, several government and state bodies can specify gasoline properties, and they may choose to use or modify consensus minimum quality standards, such as American Society for Testing Materials (ASTM). The US gasoline specifications and test methods are listed in several readily available publications, including the Society of Automotive Engineers (SAE), and the Annual Book of ASTM Standards.

2.1.2: Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure

2.1.2.1: Based on its composition, vapor pressure, expected IBP or expected EP, or combination there, of the sample is placed in one of five groups. Apparatus arrangement, condenser temperature, and other operational variables are defined by the group in which the sample falls.

2.1.2.2: A 100-mL sample is placed in a round bottom flask and heated at a rate specified for samples with its vapor pressure characteristics. Temperatures are recorded when the first drop is collected(initial boiling point), at recorded volumes of 5ml, 10ml, every subsequent 10ml interval to 90ml, 95ml and at the end of the test(end point). For gasoline samples, the temperatures associated with each incremental volume percentage recovered are converted to temperatures for each incremental volume percentage evaporated by correcting for any sample loss during the test.

2.1.2.3: At the conclusion of the distillation, the observed vapor temperatures can be corrected for barometric pressure and the data are examined for conformance to procedural requirements, such as distillation rates. The test is repeated if any specified condition has not been met.

2.1.2.4: Test results are commonly expressed as percent evaporated or percent recovered versus corresponding temperature, either in a table or graphically, as a plot of the distillation curve(ASTM.,2005).

2.1.3: Standard Test Method for density of Petroleum Products

The sample is brought to a specified temperature and a test portion is transferred to a hydrometer cylinder that has been brought to approximately the same temperature. The appropriate hydrometer, also at a similar temperature, is lowered into the test portion and allowed to settle. After temperature equilibrium has been reached, the hydrometer scale is read, and the temperature of the test portion is taken. The observed hydrometer reading is reduced to the reference temperature by means of the Petroleum Measurement Tables. If necessary, the hydrometer cylinder and its contents are placed in a constant temperature bath to avoid excessive temperature variation during the test (ASTM.,2005).

2.1.4: Standard Test Method for vapor pressure of Petroleum Products

The chilled sample cup of the automatic vapor pressure instrument is filled with chilled sample and is coupled to the instrument inlet fitting. The sample is then automatically forced from the sample chamber to the expansion chamber where it is held until thermal equilibrium at 37.8°C (100°F) is reached. In this process the sample is expanded to five times its volume (4:1 vapor-to-liquid ratio). The vapor pressure is measured by a pressure transducer. The measured vapor pressure is automatically converted to a DVPE value by the instrument. A correction to this value is necessary to account for the observed bias between the test result and that obtained by Test Method D 4953(ASTM.,2005).

2.1.5: Standard Test Method for Gum Content in Fuels by Jet Evaporation

A measured quantity of fuel is evaporated under controlled conditions of temperature and flow of air or steam. For aviation gasoline and aviation turbine fuel, the resulting residue is weighed and reported as milligrams per 100 mL. For motor gasoline, the residue is weighed before and after extracting with heptane and the results reported as milligrams per 100 mL. Recording to the following:

Weight of Gum = weight of (peaker gum) - (peaker plank) ⁄ 2000

The weight is so Alblanc worth its weight in pre-heating and weighed the purpose of heating, but if there was a difference between these two weights raises the value of the sample (glue) and then recording the output is obtained. That's where 2000 = factor (ASTM.,2005)

2.1.6: Standard Test Method for Copper corrosion.

A polished copper strip is immersed in a given quantity of sample and heated at a temperature and for a time characteristic of the material being tested. At the end of this period the copper strip is removed, washed, and compared with the ASTM Copper Strip Corrosion Standards (ASTM2005).

1a	1b	2a	2b	2c	2d	2e	3a	3b	4a	4b	4c
Slight tarnish		Moderate tarnish					Dark tarnish		corrosion		

Fig.2.1 the ASTM cupper strip corrosion standard

2.1.7 Stander test method for motor Octane Number

The Motor O.N. of a spark-ignition engine fuel is determined using a standard test engine and operating conditions to compare its knock characteristic with those of PRF blends of known octane number. Compression ratio and fuel-air ratio are adjusted to produce standard knock intensity for the sample fuel, as measured by a specific electronic detonation meter instrument system. A standard knock intensity guide table relates engine compression ratio to octane number level for this specific method. The fuel-air ratio for the sample fuel and each of the primary reference fuel blends is adjusted to maximize knock intensity for each fuel. The fuel-air ratio for maximum knock intensity may be obtained (1) by making incremental step changes in mixture strength, observing the equilibrium K.I. value for each step, and then selecting the condition which maximizes the reading or (2) by picking the maximum knock intensity as the mixture strength is changed from either rich-to-lean or lean-to-rich at a constant rate. Bracketing Procedures— the engine is calibrated to operate at standard knock intensity in accordance with the guide table. The fuel-air ratio of the sample fuel is adjusted to maximize the knock intensity, and then the cylinder height is adjusted so that standard knock intensity is achieved. Without changing cylinder height, two primary reference fuels are selected such that, at their fuel-air ratio for maximum knock intensity, one knocks harder (higher K.I.) and the other softer (lower K.I.) than the sample fuel.

A second set of K.I. measurements for sample fuel and reference fuels is required, and the sample fuel octane number is calculated by interpolation in proportion to the differences in average knock intensity readings, a final condition requires that the cylinder height used shall be within prescribed limits around the guide table value for the calculated octane number. Bracketing procedure ratings may be determined using either the equilibrium fuel level or dynamic fuel level approach. Compression Ratio Procedure— a calibration is performed to establish standard knock intensity using the cylinder height specified by the guide table for the octane number of the selected primary reference fuel. The fuel-air ratio of the sample fuel is adjusted to maximize the knock intensity under equilibrium conditions; the cylinder height is adjusted so that standard knock intensity is achieved. The calibration is reconfirmed and the sample fuel rating is repeated to establish the proper conditions a second time. The average cylinder height reading for the sample fuel, compensated for barometric pressure, is converted directly to octane number using the guide table. A final condition for the rating requires that the sample fuel octane number be within prescribed limits around that of the octane number of the single primary reference blend used to calibrate the engine to the guide table standard knock intensity condition (ASTM.,2005).

2.1.8: Method for Determine of lead concentration in gasoline by atomic absorption spectrophotometer (A.A.S)

2.1.8.1: Preparation of sample:About 30 ml of solvent methyl isoketone ware pipette and transferred into a clean volumetric flask(100ml), a 5 ml of buffer solution ware added, then a 0.1g of iodine ware dissolved in flask content, then 5 ml of gasoline ware added to flask, finally the volume was completed to the marker with isobutylketon.

2.1.8.2: Preparation of the standard

A (0.5 ppm, 1.0 ppm and 2 ppm) ware prepared from the stock lead solution(1000ppm) by dilution low.

2.1.8.3: Read of sample and standard by A.A.S

Deionized water, is zero the device was used to blank the instrument and the injected into the sample where a process of atomization, so atoms of lead in gasoline (in the path of the light from the bulb short)and the device read the focus directly (ASTM.,2005).

2.1.9: Stander test method for Oxidation stability to fuels.

The sample is oxidized in a pressure vessel initially filled at 15 to 25°C with oxygen pressure at 690 to 705 KPa and heated at a temperature between 98 and 102°C. The pressure is recorded continuously or read at stated intervals until the breakpoint is reached. The time required for the sample to reach this point is the observed induction period at the temperature of test, from which the induction period at 100°C can be calculated. Precaution: In addition to other precautions, to provide protection against the possibility of explosive rupture of the pressure vessel, the pressure vessel should be operated behind an appropriate safety shield. Recording to the following:

The number of minutes from the time the pressure vessel is placed in the bath until the breakpoint has been reached is the observed induction period at the temperature of the test. Method of Calculation—Calculate the induction period at 100°C from one of the following equations:

(a) When the test temperature is above 100°C:
Induction period at 100°C = (IPt)(1 + 0.10)(t a – 100) (b) When the test temperature is below 100°C: Induction period at 100°C, min =(IP t)/(1 + 0.101)(100 – tb)
where:
IPt = induction period, min, at the temperature of the test.
t_a = test temperature when above 100°C, °C, and
t_b = test temperature when below 100°C, (ASTM., 2005).

2.1.10: Standard Test Method for Sulfur in Gasoline by Energy-Dispersive X-ray Fluorescence Spectrometry (D6445)

The sample is placed in the beam emitted from an X-ray source. The resultant excited characteristic X radiation is measured, and the accumulated count is compared with counts from previously prepared calibration standards to obtain the sulfur concentration in mg/kg. One group of calibration standards is required to span the concentration 5 to 1000 mg/kg sulfur (ASTM., 2005).

2.2: Method for Addition of Di isopropyl ether and Meringa oil to reformate Sudanese gasoline

Additives are gasoline soluble chemicals mixed with reformate gasoline to enhance octane number of gasoline. Typically, they are derived from petroleum based raw materials and their fractions, chemistry are highly specialized. Antiknock compounds increase the antiknock quality of gasoline, because the amount of additive needed is small, they are the lowest cost method for increasing octane number compared with changing gasoline chemistry *P*[25]*P*. All components are added to the Sudanese gasoline at different vol% as follow:

2.2.1: A1000 ml gasoline was prepared at refrigerator temp. In glass container had fitting Cover.

2.2.2: Octane number of gasoline was measured by CFR engine, and all properties of gasoline detected before additive.
2.2.3: Four glass container were filled with 1000ml of Sudanese gasoline and added one of friendly Isopropyl ether to these containers with shaking by using pipette in different concentrations.
2.2.4: Octane number of these blend were measured by CFR engine, and all properties was detected after adding isopropyl ether.
2.2.5: Repeat the 3 and 4 with Moringa oil.

3. Results and discussion

In this is reformed gasoline was prepared, moringa oil and Di Isopropyl (5,10%) ether were added to the reformat gasoline which was produced in Al Khartoum refinery to improving octane number. Result obtained shown in tables (3.1), (3.2).

Table.3.1: shown results of reformat gasoline before and after adding moringa oil (5, 10%).

Test name	Results of reformat Gasoline before added		Results after adding 50ml from Moringa oil to 1000ml reformat gasoline		Results after adding 100ml from Moringa oil to 1000ml reformat gasoline	
Distillation	IBP	37.9°C	IBP	35.7 °C	IBP	29.5 °C
	10%	58.5°C	10%	49.O °C	10%	40.9 °C
	5%	97.2 °C	50%	88.9 °C	50%	78.1 °C
	90%	159.0°C	90%	152.3 °C	90%	138.8 °C
	FBP	190.5°C	FBP	184.4 °C	FBP	175 °C
Density	736.4 K/m³(150°C)		701.2 K/m³(150°C)		689.6 K/m³(150°C)	
Vapor pressure	52.5 KPa(37.8°C)		59 KPa(37.8°C)		62.2 KPa(37.8°C)	
Gum content	0.8 mg/100ml		0.8 mg/100ml		0.95 mg/100ml	
Copper corrosion	1a		1a		1a	
Lead percentage	0.oo1mg/L		0.oo2mg/L		0.oo4mg/L	
Oxidation stability	504 min		304 min		235 min	
Sulfur percentage	58.49 mg/L		49.3 mg/L		40 mg/L	
Pressure result in number engine	0.503KPa		0.465KPa		0.452KPa	
Motor octane number	88.5		91.1		92	

Table 3.2: shown results of reformat gasoline before and after adding Di Isopropyl ether (5, 10%).

Test name	Results of reformat Gasoline before added		Results after adding 50ml from to Di Isopropyl ether to 1000ml reformat gasoline		Results after adding 100ml from Di Isopropyl ether to 1000ml reformat gasoline	
Distillation	IBP	37.9°C	IBP	37.5 °C	IBP	36.9 °C
	10%	58.5°C	10%	58 °C	10%	58.9 °C
	5%	97.2 °C	50%	98 °C	50%	99.3 °C
	90%	159.0°C	90%	158.2 °C	90%	157.6 °C
	FBP	190.5°C	FBP	188.2 °C	FBP	185.9°C
Density	736.4 K/m³(150°C)		730 K/m³(150°C)		704 K/m³(150°C)	
Vapor pressure	52.5KPa(37.8°C)		51KPa(37.8°C)		49.1KPa(37.8°C)	
Gum content	0.8 mg/100ml		0.8 mg/100ml		0.8 mg/100ml	
Copper corrosion	1a		1a		1a	
Lead percentage	0.oo1mg/L		0.oo1mg/L		0.oo1mg/L	
Oxidation stability	494Mints		450 mints		403mints	
Sulfur percentage	58.49mg/L		58.49mg/L		58.49mg/L	
Pressure result in number engine	0.503KPa		0.477KPa		0.451KPa	
Motor octane number	88.5		93.2		95	

The results obtained from the distillation give a strong indicator that the quality of the gasoline has improved after two additions (5, 10%). As the initial boiling point (IBP) being lowered, consequently some of the LPG would be covered into fuel (Seddon D.,2001). The decrease in the (IBP) which flowing the additions indicate that the quality of gasoline has increased. But ASTM assigned a value for the FBP (250°C) not to be exceeded because kerosene is the separated at this temperature. This property (distillation) is not important for the addition of moringa oil or Di Isopropyl ether. Because these additions only raise the octane number after the distillation and refining processes. But it gives an interpretation about the raising or lowering of the octane number (Ali. E., 2006).

No limits had been assigned for the density, vapor pressure, distillation except the FBP, by ASTM. Because it depends to a greater extent on the temperature of the country, but the refineries has assigned limits to these physical parameters. The results obtained fall within the boundaries assigned by Khartoum refinery.

The percent of gum in gasoline affect the stability of gasoline, which can be a (+ve) or (–ve) effect on the octane number and the quality of the gasoline. This explain why ASTM has assigned boundaries to the percentage of the gum refer to **table (3.3),** but we find the increment of gum after the 10% addition of moringa oil which raised the percentage to 0.59 g/100ml within the permissible values.

The test of cupper corrosion is very important regard to the gasoline, because this causes corrosion and fatigue in gasoline tank, the engine and also the exhaust (Perdiha A.,2006). ASTM has put a color table which to determine the corrosion of a cupper plate immersed in a gasoline sample, and the comparison with ASTM cupper strip corrosion standard. The result obtained for bath addition is within permissible limits. the result (1a) of the cupper corrosion indicated the good quality of the gasoline after the additions.

It worth mention that the amount of lead in the results has increased from 0.001mg/L to 0.002 mg/L, it seems that the oil contains a small percentage of lead. This may explain the reason why the moringa oil has raised the octane number. This is attributed to the well known fact the lead is capable of converting the hydrocarbon open chains into cyclic compounds (Ghosh .P., 2000). But we find the lead content of gasoline not altered after the addition of Di Isopropyl ether.

One of most important properties which should be measured in order to access the quality of gasoline, is the stability which give clue on the circumstances of the storing the product, and also the heat required to start the combustion of gasoline inside the engine. The results obtained from the oxidation stability test it within the permissible range of ASTM as shown in table (3.3). Except when adding moringa oil (10%) we found the stability 235 mints that are out of permissible range this is attributed to the high density of the oil and the addition of a larger quality 10% instead of 5%.

When adding moringa oil (5%,10%) respectively it was observed that the sulfur content was lowered appreciably from 58.49ppm to 49.30ppm, this reflects a high improvement in quality because high sulfur content causes corrosion and lowers the octane number. Also the sulfur content was reduced upon addition of Di Isopropyl ether. Additives are classified as sulfur elimination materials.

Table.3.3: explained the permissible range by ASTM

Test name	Permissible range	ASTM
Distillation	FBP ≤250°c	D86-99a
Gum content	0.5-2mg/100ml	D381-99
Cupper corrosion	1a or 1b	D183-91
Oxidation stability	>240mints	D525-99a
Sulfur content	≯250 ppm	D4294-89
Lead content	≯ 0.001 ppm	D3341-91

ASTM has set table for pressures products from CFR engine with octane number, the raising of ON 2.6 with adding of 5% moringa oil to the reformate gasoline can be considered a clear indicator that the oil can raise the octane number and consequently improve the quality of gasoline. As this addition is not accompanied with any rejected bad measurable properties, in contrast the addition of 10% moringa oil to the reformate gasoline raises the ON to 4.5 but it give a value 235 mint stability with lower than recommended value of 250 mint by ASTM. The raising of ON and addition of moringa oil is attributed to the ability of the oil to convert the hydrocarbon chains into cyclic compounds or increasing the branched chains in gasoline, also to the ability of the oil in sulfur elimination (Ghosh .P., 2006).

The addition of Di Isopropyl ether (5, 10%) raising ON to 4.7 and 6.5 respectively, holding the other properties inside the range allowed by ASTM and Sudanese standards. Previous studies had shown that the oxygenic legends can raise the ON by increasing the branching of the hydrocarbon chains.

Comparison between rate of octane number when add alternative additives shown in **Fig.3.1.**

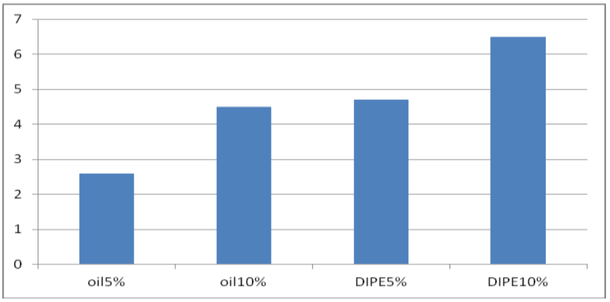

Fig. 3.1: Comparison between rate of MON Increasing of Different additives and different percentage.

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