

Physicochemical Properties of Blended Gasoline Samples Produced from Khartoum Refinery in Sudan

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Abstract: The physical and chemical properties of gasoline samples produced after Blending (BG) were studied; the samples (Tank1, Tank2, Tank3, and Tank4) were taken from Khartoum refinery (RFCC unit) in Sudan. Gasoline samples were tested according to the American society for testing and materials (ASTM), Tests included distillation , sulfur content, density, vapor pressure, oxidation stability , copper strip corrosion, gum existence, lead content, and octane number determination by Cooperative Fuels Research (CFR engine). Results obtained revealed that, the Physicochemical properties of BG samples agreed well within the limits assigned by ASTM and Khartoum refinery, except the motor octane number (MON) which was found to be 87, 87.9, 87.5 and 87.7 for T1, T2, T3 and T4 respectively, these values were found lower to be using as fuels of high quality internal combustion engine.

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Key words: Physicochemical properties, Blended gasoline, Khartoum refinery, motor octane number

1-Introduction

Gasoline is a mixture of volatile, flammable liquid hydrocarbons derived from petroleum and used as fuel for internal-combustion engines. It is also used as a solvent for oils and fats. Gasoline became the preferred automobile fuel because of its high energy of combustion and capacity to mix readily with air in a carburetor (Nichols.,1997). 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. 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 (Mcnaair.,2001).

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 (Domask., 1984).

Aviation gasoline contains smaller proportions of both the less-volatile and more-volatile components than automobile gasoline, the antiknock characteristics

of a gasoline—its ability to resist knocking, which indicates that the combustion of fuel vapour 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 unleaded gasoline and 10 percent ethanol (ethyl alcohol) (Zagentd, 2001). Gasohol burns well in gasoline engines and is a desirable alternative fuel for certain applications because of the renewability of ethanol, which can be produced from grains, potatoes, and certain other plant matter (Sax., 1989).

Gasoline blending

Streams of gasoline blending are refined from petroleum, or crude oil, an extremely complex substance. The hydrocarbon molecules in crude oil may include from one to 50 or more carbon atoms. At room temperature, hydrocarbons containing one to four carbon atoms are gases; those with five to 19 carbon atoms are usually liquids; and those with 40 or more

carbon atoms are typically solids. Figure (1.1) below shows the typical carbon chain lengths found in the proposed HPV (Genital Human Papilloma virus) test

plans and demonstrates the overlap that occurs (Lovell, et al. 1981).

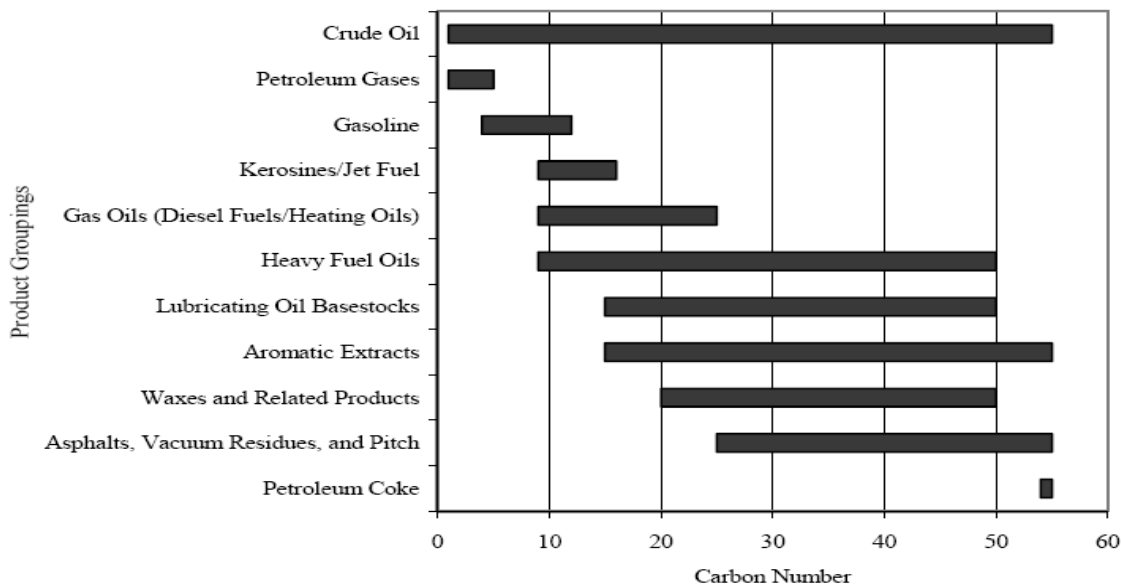


Fig.1.1: Typical carbon chain lengths

Petroleum refining involve distillation as well as chemical treatment. Catalysts and pressure are used to separate and combine the basic types of hydrocarbon molecules into petroleum streams which have the characteristics needed for blending commercial petroleum products. However streams used in the blending of gasoline must generally fall in a boiling range -20 - 230 oC and a carbon number distribution of C4 - C12, gasoline are blended from several petroleum refinery process streams that are derived by the following methods: direct distillation of crude oil, catalytic and thermal cracking, hydrocracking, catalytic reforming, alkylation, and polymerization (Lefter, 1985).

Hydrocracking, which consists of cracking in the presence of added hydrogen, permits wide variations in yields of gasoline and furnace oils to meet seasonal demand changes and can effectively process hard to crack stocks. However since hydro cracked stocks lack the high octane olefins present in catalytically cracked stocks, they must be reformed (Lefter.,1985). Reforming process convert low octane gasoline range hydrocarbons into higher octane ones. Thermal reforming has been almost completely replaced by catalytic reforming. Most reforming catalysts are bimetallic catalysts consisting of platinum with another promoting metal, such as rhenium, alkylation converts refinery gases into gasoline range liquids of exceptionally high antiknock quality.

However, the process is costly and is not commonly used in gasoline production (Gosh., etal.2006).

Polymerization combines two or more low molecular weight olefin gases into higher molecular weight olefin liquids suitable for gasoline blending or for use as chemical feed stocks. However, because olefinic liquids have low antiknock quality and the reactants, olefin gases, are valuable chemical feeds. The polymerization process is no longer widely used to produce gasoline blend streams ,the need for high quantity fuels, having increased resistance to knock over a wide range of engine operating conditions is of paramount significance in current engine operation. Careful refining and blending of fuel components can produce a fuel of sufficiently increased knock resistance to satisfy engine requirements under certain stressed conditions oxygenates are added into gasoline in order to increase the overall octane numbers and improve combustion efficiency. In view of lead phase out schedules adopted, various options for octane enhancement have been explored(Lefter.,1985).

2- Materials and methods

2.1: Materials

All chemicals used were of analytical reagent grade (AR) and of highest purity degree available. gasoline product was taken from Khartoum refinery in Sudan.

2.2: Methods

Gasoline are 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 (Ezeldin and Massad, 2015).

Standard test method for distillation of petroleum products at atmospheric pressure

- a-** 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.
- b-** 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 5 mL, 10 mL, every subsequent 10mL interval to 90 mL, 95 mL 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.
- c-** 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.
- d-** 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).

Standard test method for density of petroleum products

A small volume (approximately 0.7 mL) of liquid sample is introduced into an oscillating sample tube and the change in oscillating frequency caused by the change in the mass of the tube is used in conjunction with calibration data to determine the density of the sample (ASTM., 2005).

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 vapour – to - liquid ratio). The vapour 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.

DVPE was calculated according using the equation below. This corrects the instrument reading for the relative bias found in the 1991 inter laboratory cooperative test program (see Note 10) between the dry vapor pressure measured in accordance with test Method D 4953, Procedure A and this test method:

$$DVPE = (0.954 X) + A$$

Where:

X = measured total vapor pressure, in units consistent with A, and A = 1.94 kPa (0.281 psi), (ASTM.,2005).

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:

$$\text{Wight of Gum} = \frac{\text{weight of (peaker gum) - (peaker plank)}}{2000}$$

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).

Standard test method for copper strip corrosion

A polished copper strip is immersed in a given quantity of sample and heated at a temperature (200°C) and for a time (2 hours) 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 shown in the figure below (ASTM.,2005).

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

The ASTM copper strip corrosion standard

Standard test method for motor Octane Number

The Motor ON 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).

Determination of lead concentration in gasoline by atomic absorption spectrophotometer method (A.A.S)

a: Preparation of sample

about 30 mL of solvent methyl Isoketone were taken, a 5 mL of buffer solution were added, then 0.1g of iodine was weighed and transferred to the solution, then 5 mL of gasoline were added to the solution, finely the solution was completed to the mark in a 100 mL volumetric flask with iso butyl ketone (ASTM.,2005)..

b: Preparation of the standard lead (II) solution

Preparation of standard lead (II) solutions (0.5, 1.0 and 2.0 ppm).

C: Blank of instruments

Deionized water, is zero the device use 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(Kerr and Sarede.,1997).

Standard test method for oxidation stability of 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:

$$\text{Induction period at } 100^{\circ}\text{C} = (\text{IP}_t) (1 + 0.10) (t_a - 100)$$

(b) When the test temperature is below 100°C:

$$\text{Induction period at } 100^{\circ}\text{C, min} = (\text{IP}_t) / (1 + 0.101)(100 - t_b)$$

where:

IP_t = 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).

Standard test method for determination of sulfur content in gasoline by energy dispersive X-ray fluorescence spectrometry

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).

3- Results and discussion

Physicochemical properties of BG samples is checked by applying many tests according to American Society for Testing and Materials (ASTM). These tests included: distillation, density, vapour pressure,

stability, Copper corrosion, lead content, gum content, sulfur content and octane number. The experimental work was conducted at central laboratories of Khartoum refinery (Algily, north Khartoum-Sudan) and central petroleum laboratories (CPL), alamarat, str. 61, Khartoum- Sudan.

The physical properties of gasoline Represented included: Distillation, Density and Vapour Pressure. The distillation properties were determined by: IBP, 10%, 50%, 90% and FBP the results of distillation test shown in Table 3.1.

Table 3.1: Distillation percentage without boiling point temperature

Sample	T1	T2	T3	T4
Initial Boiling point(IBP) °C	38.4	37.4	39	39.9
10% °C	89	87.7	88.3	88.8
50% °C	98.1	96.5	97.1	97.9
90% °C	160.2	157.1	159.2	159.5
Final Boiling Point(FBP) °C	192	189.6	190.3	191

The limits of IBP of gasoline it is not assigned by ASTM or Khartoum refinery This may attributed to the conversion of some liquid petroleum gases (LPG) into fuel (Gibbs and Bonazza.,2008). But ASTM assigned that, the value of FBP could not exceed 250°C. This

refers to probability of separation of kerosene at this temperature value. The obtained results of FBP of T1,T2,T3 and T4 lower than 250 °C within the range assigned by ASTM. The results of distillation point were shown in Figures 3.1, 3.2,3.3 and 3.4.

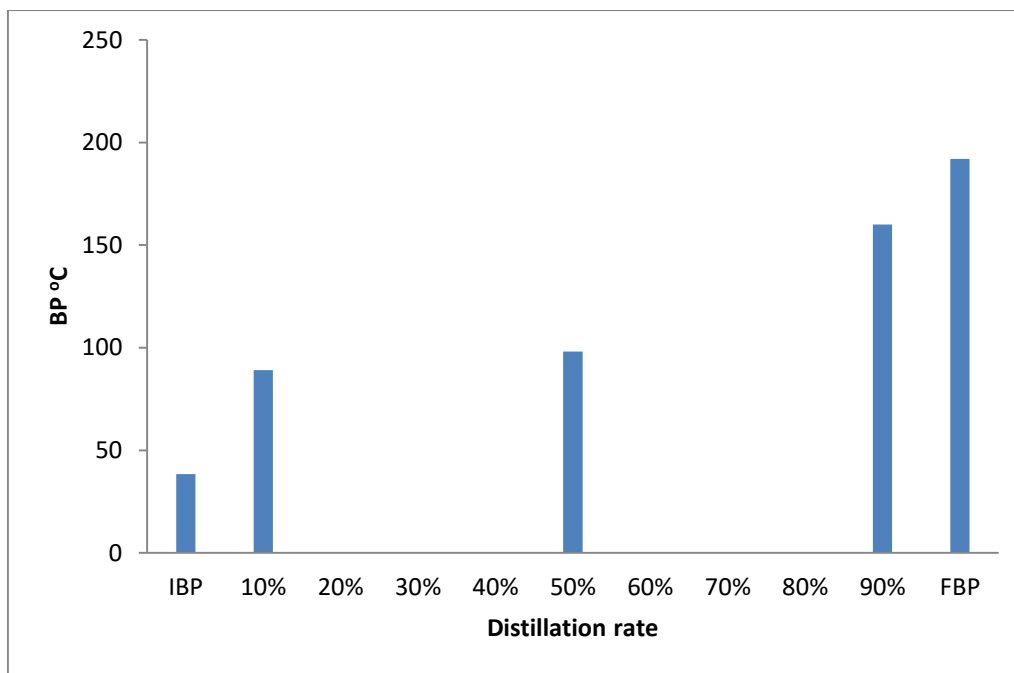


Fig 3.1: Comparison between distillation rate & boiling point of T1 sample.

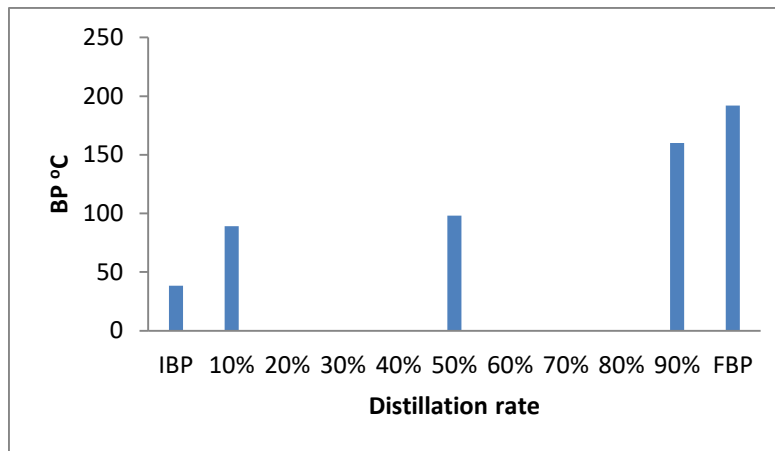


Fig3.2: Comparison between distillation rate & boiling point of T2 sample.

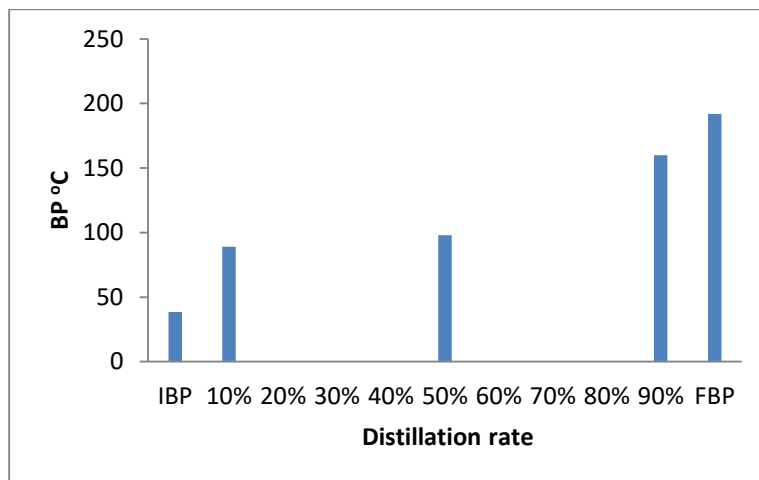


Fig3.3: Comparison between distillation rate & boiling point of T3 sample

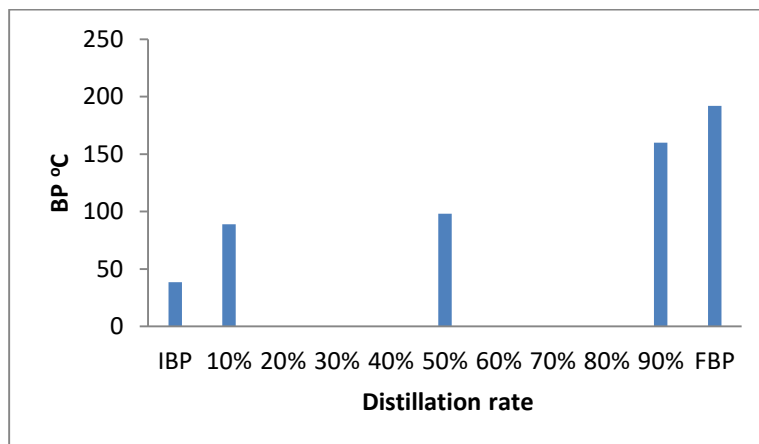


Fig3.4: Comparison between distillation rate & boiling point of T4 sample

The density and vapor pressure properties of gasoline are very important, because increased density leads to a decrease in the octane number, and increased the vapour pressure leads to increase in the octane number; results are shown in table 3.2.

Table 3.2: Density and vapour pressure of samples

sample	Density (kg/m ³)	Vapour pressure (kpa)
T1	738	52.5
T2	736.2	55
T3	737.1	53.6
T4	736.9	54.8

No limits had been assigned for the density and vapor pressure by ASTM, because they depend to a greater extent on the temperature of the country, but the refineries has assigned limits to these physical parameters as shown in Table 3.3.

Table 3.3: Limits of physical parameters gasoline assigned by Khartoum refinery

Test	Summer	Winter
Density	>740 kg/m ³	>740 kg/m ³
Vapour pressure	40- 67 KPa	40 – 85KPa

According to the assigned results of density and vapour pressure, the obtained results in Tables 3.2 appears to be in permissible range. The results of density and vapour pressure are represented in Figurers 3.5 & 3.6 respectively.

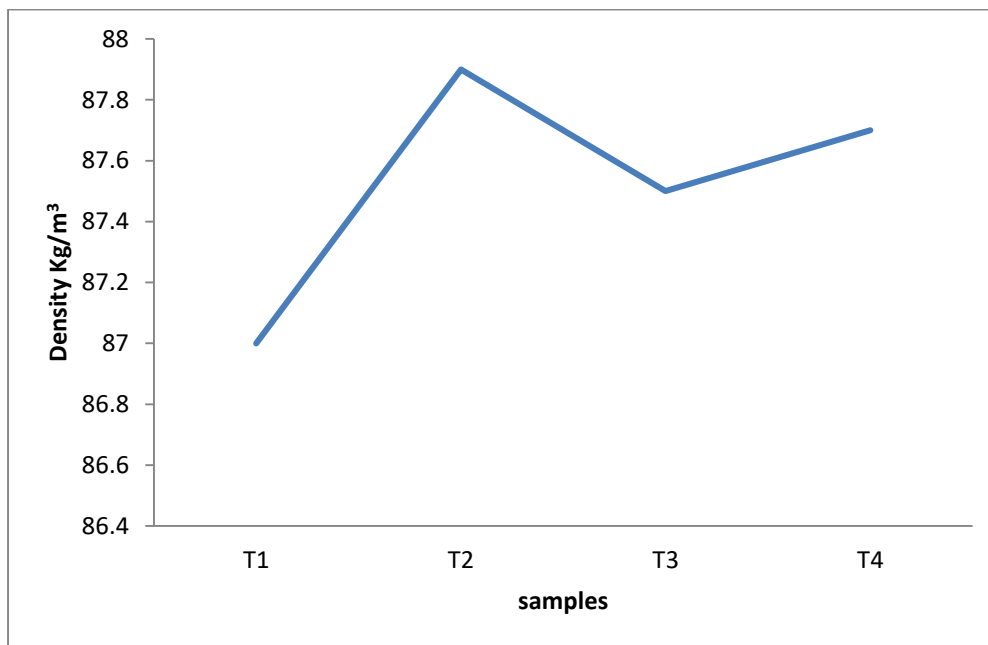


Fig 3.5: Comparison between density results of samples

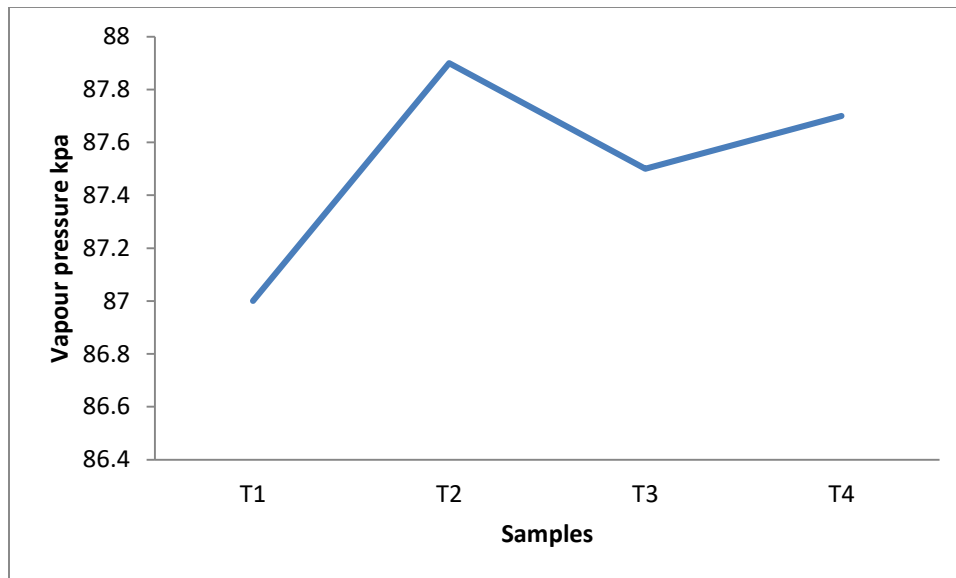


Fig3.6: Comparison between Vapour pressure results of samples

The chemical properties of gasoline were also studied which include Gum existence, copper strip corrosion, lead content, oxidation stability, sulfur content and MON .

The percent of gum effect on the stability of gasoline, which can be a (+ve) or (-ve) and affect on the octane number and hence quality of gasoline, Table 3.4 shows the results of gum content obtained

Table 3.4 : Gum existence of samples

Sample	T1	T2	T3	T4
Gum existence(mg/100mL)	0.8	0.8	0.8	0.8

ASTM has assigned boundaries to the percentage of the gum refer to Table (3.10). We find the gum existence of all samples(T1, T2, T3 and T4) stable(0.8 mg/100ml) , that results appears to be in permissible range.

The test of copper corrosion is very important regard to the gasoline, because this causes corrosion and fatigue in gasoline tank, the engine and also the exhaust (Twu., et al. 1999). ASTM has put a colour table which to determine the corrosion of a copper plate immersed in a gasoline sample, and the comparison with ASTM copper strip corrosion standard, Table 3.5 shows the results of copper strip properties.

Table 3.5: copper strip corrosion of samples

Sample	T1	T2	T3	T4
Corrosion	1a	1a	1a	1a

The results obtained for bath addition is within permissible limits. The result (1a) of the copper corrosion indicated the good quality of the BG samples.

The BG is an unleaded gasoline, but the percent in this samples due to presence of crude oil and attendant gasoline from the distillation process. The results of lead percentage in the BG samples were shown in Table 3.6.

Table 3.6: The lead content of BG samples

Samples	T1	T2	T3	T4
Lead percent ppm	0.0001	0.001	0.00023	0.00042

ASTM assigned limit of lead percent in gasoline shown in Table (3.10), the obtained results within the permissible range assigned by ASTM, sample T2

showed the highest concentration of lead. The comparison between lead content in BG was shown in Fig 3.7.

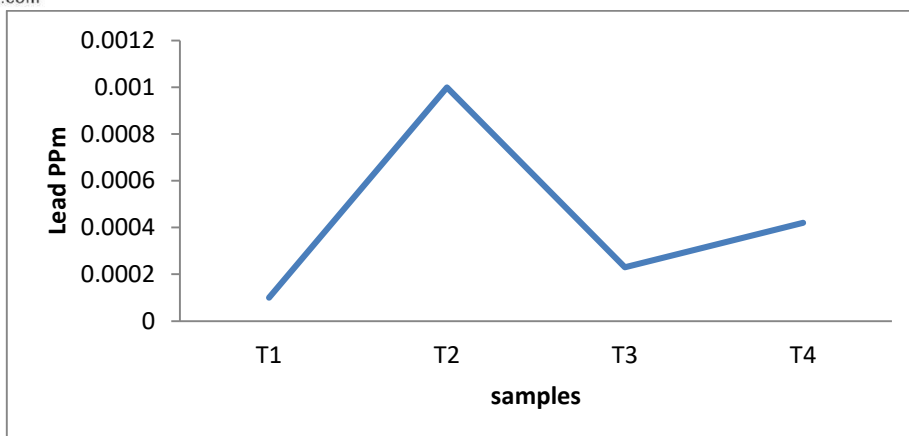
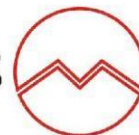


Fig3.7: Comparison between lead content results

Oxidation stability of gasoline one of the most important properties which should be measured in order to assess the quality of gasoline, can be defined as the oxidation stability which give clue on the circumstances of the product storing, and also the heat required to start the combustion of gasoline inside the engine (Kerr and Richard., 2003), the results of oxidation stability of BG samples were shown in Table 3.7.

Sample	T1	T2	T3	T4
Oxidation stability(min)	490	550	522	534

The results obtained from the oxidation stability test are within the permissible range of ASTM as shown in table (3.10), sample T2 showed the highest value. The comparison between oxidation stability of BG was shown in Fig 3.8.

Table3.7: oxidation stability of BG samples

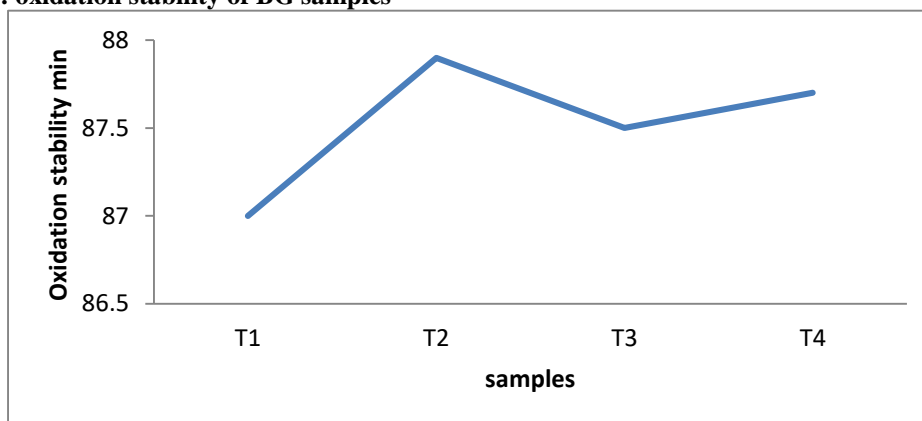


Fig3.8: Comparison between Oxidation stability results

The sulfur content in gasoline is very important because it effect on octane number value. The results of sulfur content were shown in Table 3.8.

Table 3.9: sulfur content of BG samples

Sample	T1	T2	T3	T4
Sulfur content ppm	60.1	60.1	60.1	60.1

Increase sulfur content in gasoline showed decreased of octane number and increasing of corrosion, the sulfur concentration of BG samples was stable.

Table.3.10: The permissible range by ASTM

Test name	Permissible range	ASTM
Distillation	FBP ≤250°c	D86-99a
Gum content	0.5-2mg/100ml	D381-99
Copper 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, because the CFR engine do not detect the octane number directly but the detector has been determination the pressure product from fire room, the motor octane number recorded from Table 3.11, (ASTM.,2005).

Table 3.11: Guide Table for Standard Knock Intensity at Standard Barometric Pressure. Venturi Motor Octane Numbers for Digital Counter Readings(40-96)

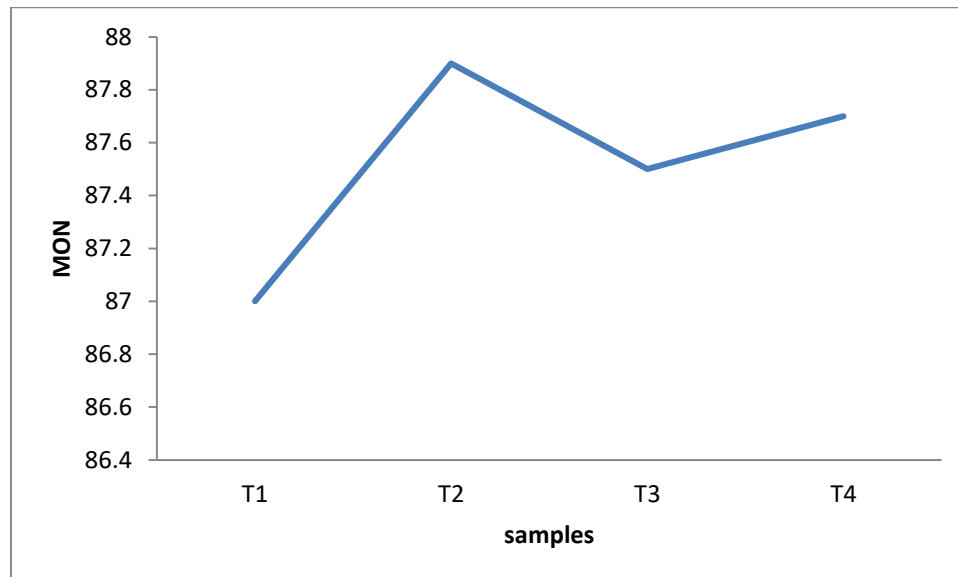
Motor Octane Number	Dial Indicator, in.									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
40	1.018	1.018	1.017	1.017	1.016	1.016	1.015	1.015	1.014	1.014
41	1.013	1.013	1.012	1.012	1.011	1.011	1.010	1.010	1.009	1.009
42	1.008	1.008	1.007	1.007	1.006	1.006	1.005	1.005	1.004	1.004
43	1.003	1.003	1.002	1.002	1.001	1.001	1.000	1.000	0.999	0.999
44	0.998	0.998	0.997	0.997	0.996	0.996	0.995	0.995	0.994	0.994
45	0.993	0.992	0.992	0.991	0.991	0.990	0.990	0.989	0.989	0.988
46	0.988	0.987	0.987	0.986	0.986	0.985	0.985	0.984	0.983	0.983
47	0.982	0.982	0.981	0.981	0.980	0.980	0.979	0.979	0.978	0.978
48	0.977	0.976	0.976	0.975	0.975	0.974	0.974	0.973	0.972	0.972
49	0.971	0.971	0.970	0.970	0.969	0.968	0.968	0.967	0.967	0.966
50	0.966	0.965	0.964	0.964	0.963	0.963	0.962	0.961	0.961	0.960
51	0.960	0.959	0.958	0.958	0.957	0.957	0.956	0.956	0.955	0.954
52	0.954	0.953	0.952	0.952	0.951	0.951	0.950	0.949	0.949	0.948
53	0.948	0.947	0.946	0.946	0.945	0.944	0.944	0.943	0.943	0.942
54	0.941	0.941	0.940	0.939	0.939	0.938	0.937	0.937	0.936	0.936
55	0.935	0.934	0.934	0.933	0.932	0.932	0.931	0.930	0.930	0.929
56	0.928	0.928	0.927	0.926	0.925	0.925	0.924	0.923	0.923	0.922
57	0.921	0.921	0.920	0.919	0.919	0.918	0.917	0.917	0.916	0.915
58	0.914	0.914	0.913	0.912	0.912	0.911	0.910	0.909	0.909	0.908
59	0.907	0.907	0.906	0.905	0.904	0.904	0.903	0.902	0.901	0.901
60	0.900	0.899	0.898	0.898	0.897	0.896	0.895	0.894	0.894	0.893
61	0.892	0.891	0.891	0.890	0.889	0.888	0.888	0.887	0.886	0.885
62	0.884	0.884	0.883	0.882	0.881	0.880	0.880	0.879	0.878	0.877
63	0.876	0.875	0.875	0.874	0.873	0.872	0.871	0.870	0.870	0.869
64	0.868	0.867	0.866	0.865	0.865	0.864	0.863	0.862	0.861	0.860
65	0.860	0.859	0.858	0.857	0.856	0.855	0.854	0.853	0.852	0.852
66	0.851	0.850	0.849	0.848	0.847	0.846	0.845	0.844	0.843	0.843
67	0.842	0.841	0.840	0.839	0.838	0.837	0.836	0.835	0.834	0.833
68	0.832	0.831	0.830	0.829	0.828	0.828	0.827	0.826	0.825	0.824
69	0.823	0.822	0.821	0.820	0.819	0.818	0.817	0.816	0.815	0.814
70	0.813	0.812	0.811	0.810	0.809	0.808	0.807	0.806	0.805	0.804
71	0.803	0.802	0.801	0.800	0.799	0.798	0.797	0.796	0.794	0.793
72	0.792	0.791	0.790	0.789	0.788	0.787	0.786	0.785	0.784	0.783
73	0.782	0.781	0.780	0.778	0.777	0.776	0.775	0.774	0.773	0.772
74	0.771	0.770	0.768	0.767	0.766	0.765	0.764	0.763	0.762	0.761
75	0.759	0.758	0.757	0.756	0.755	0.754	0.752	0.751	0.750	0.749
76	0.748	0.747	0.745	0.744	0.743	0.742	0.741	0.740	0.738	0.737
77	0.736	0.735	0.734	0.732	0.731	0.730	0.729	0.728	0.726	0.725
78	0.724	0.723	0.721	0.720	0.719	0.718	0.717	0.715	0.714	0.713
79	0.712	0.710	0.709	0.708	0.707	0.705	0.704	0.703	0.702	0.700
80	0.699	0.698	0.696	0.695	0.694	0.693	0.691	0.690	0.689	0.687
81	0.686	0.685	0.683	0.682	0.681	0.680	0.678	0.677	0.676	0.674
82	0.673	0.672	0.670	0.669	0.668	0.666	0.665	0.664	0.662	0.661
83	0.660	0.658	0.657	0.656	0.654	0.653	0.651	0.650	0.649	0.647
84	0.646	0.645	0.643	0.642	0.640	0.639	0.638	0.636	0.635	0.634
85	0.632	0.631	0.629	0.628	0.627	0.625	0.624	0.622	0.621	0.620
86	0.618	0.617	0.615	0.614	0.613	0.611	0.610	0.608	0.607	0.606
87	0.604	0.603	0.601	0.600	0.599	0.597	0.596	0.594	0.593	0.591
88	0.590	0.589	0.587	0.586	0.584	0.583	0.581	0.580	0.578	0.577
89	0.576	0.574	0.573	0.571	0.570	0.568	0.567	0.565	0.564	0.563
90	0.561	0.560	0.558	0.557	0.555	0.554	0.552	0.551	0.550	0.548
91	0.547	0.545	0.544	0.542	0.541	0.539	0.538	0.537	0.535	0.534
92	0.532	0.531	0.529	0.528	0.526	0.525	0.524	0.522	0.521	0.519
93	0.518	0.516	0.515	0.513	0.512	0.511	0.509	0.508	0.506	0.505
94	0.503	0.502	0.500	0.499	0.498	0.496	0.495	0.493	0.492	0.490

The result of MON was shown in table 3.12.

Table 3.12: MON of BG samples

Sample	T1	T2	T3	T4
MON	87	87.9	87.5	87.7

The obtained results of octane number test revealed that: the MON values of BG samples were lower and need to improvement so used as fuels to movement internal composition engines. Sample T2 showed the highest ON value but sample T1 showed the lost ON value, the comparison between ON values of BG samples was shown in Fig3.9.

**Fig3.9: Comparison between MON values of BG samples**

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