Some mechanical, optical, miscellaneous and thermal properties for the local samples of Gas oil and Diesel fuels

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Abstract

Some of mechanical, optical, miscellaneous and thermal properties as density (d), Specific gravity (Sp. gr.), thermal expansion efficient (α), Aniline point (A.P), Diesel index (D.I), Refractive index (R.I), heat of combustion (gross calorific value) (Q), heat of Latent (L) and the percentage of hydrogen (%H) , the acidity and %ash were determined. The ratio of some impurity and the standardization of these samples to the usage were determined also. From this studied that show the addition of kerosene to gas oil (at slight amount of it in local's market) may be good the storage property, so the sample (2) is making high value of thermal expansion compared with other samples.

In sprit of, the values of Sp. gr of samples 6,7 &8 were occurred in standard range[19], but the amount of %Ash may be very high that caused the damage of car's engine in the little time.

الخلاصة

تضمنت الدراسة تحديد بعض الصفات الميكانيكية، والضوئية، والغروية (الميسيلات)، والحرارية للعينات المدروسة مثل الكثافة (d)، الوزن النوعي (Sp. gr.)، معامل التمدد الحراري (α)، درجة الانلين (A.P)، معامل الديزل(D.I)، ومعامل الانكسار $(R.I)$، و حرارة الاحتراق (القيمة الحرارية العليا (Q)، والحرارة الكامنة (L)، والنسبة المئوية للهيدروجين (%H) ، والحامضية، % للرماد. كما تم تحديد نسبة بعض الشوائب ومدى مطابقة هذه النماذج لمتطلبات الاستخدام. من خلال هذه الدراسة وجد ان اضافة الكيروسين الى الكاز أويل من قبل الباعة المتجولين (عند حدوث شحة محلياً) سوف يزيد من كفاءة الخزن؛ لكونه يزيد من قيمة معامل تمدده الحراري مقارنة بالعينات قيد الدراسة.

بالرغم من كون قيم الوزن النوعي للعينات 6،و7،و8 تقع ضمن القيم القياسية الا انها تمتلك قيم عالية جداً من النسبة المئوية للرماد وهذا سوف يسبب تلف وقصر عمر محرك السيارة.

Introduction

Petroleum means ((rock oil)) or ((mineral oil)) which derived from the Latin words: Petra (rock) and Oleum (oil) [1].

The earlier hypotheses on the orginal of petroleum postulated its generation from inorganic materials such as water acting on metallic carbidies or water and CO_2 interacting with alkali and alkaline earth metals according to Berthelot hypothese[2,3]:

$$CaCO_3 \rightarrow CaO + CO_2 \xrightarrow{Alkali\ metals} CaC_2 \xrightarrow{+H_2O} HC \equiv CH$$

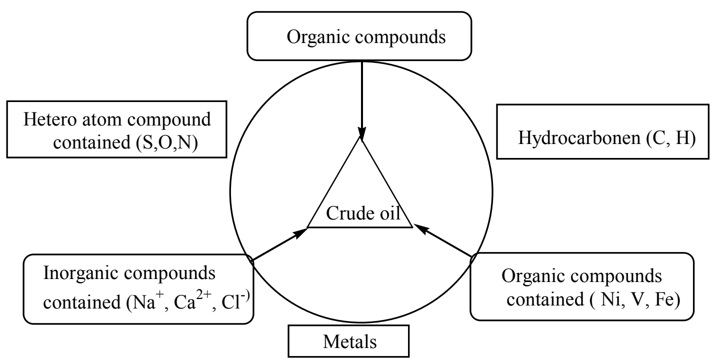
$$Crude\ oils\ or\ Petroleum \ \hookleftarrow$$

Mabbery[4] postulated that crude oils are mainly composed of hydrocarbons belonging to a few homologous series, that was explained in table (1)[1]:

Table (1): Element Composition Wt % Range for crude oils

The elements	Element composition Wt % range
Carbon	83.9 - 86.8
Hydrogen	11 - 14
Sulfur	0.06 - 8
Nitrogen	0.02 - 1.7
Oxygen	0.08 -1.82
Metals	0.0 - 0.14

Crude oils are classified into a variety of type [1,2]; ranging from light colored oils (consisting mainly of gasoline), to black, nearly solid asphalt. That depended on the diagram of chemical constitution of petroleum[2]:

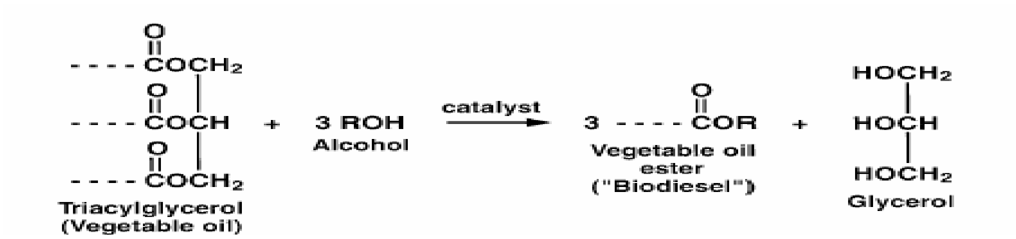


In the recently, the oil was important source of energy, therefore the researches were studied and usage all the types of the heavy and asphalt oils[5] to change it's from complex to simple derivatives oil which can be used in industrial usage[6,7].

Luma and Coworkers[8] determined some physical and chemical properties for different countries of gasoline with Iraq's gasoline and kerosene to know which of them are best to use. In other research, some mechanical, optical and thermal properties for different samples of petroleum lubricants were determined by Luma[9].

The lubricating properties of diesel are important, especially for rotary and distributor type fuel injection pumps, therefore Grigg[10] had used the lubrication of fuel which not directly provided it by the viscosity of the fuel, but by other components in fuel which prevent wear on contacting metal surface.

Diesel[11] reported about the historical perspective on vegetable oil-based diesel fuels by using the next transesterification reaction:



Biodieseal [12,13] was more important compeared with petroleum fuel because it reduced the carbon oxides CO_x, sulfide oxide SO_x and other compounds in atmosphere.

Lacey and Westbook[14] had put the additional lubricity test, by using biodiesel which consist of methyl ester of soybean oil had excellent suffing and adhesive wear resistance that exceeds those of the best conventional diesel fuel.

API[15] and, Tuttle[16] with Kuegelgen had tabulated the properties for each diesel fuel (No. 2) and biodiesel which may be near from other like: chemical forma equal $((C_8 - C_{25})$ & $(C_{12} - C_{22}))$, M. Wt equal (≈ 200) & (≈ 292), Sp. Gr equal (0.85) & (0.88), ………., H% equal (13) & (12) respectively.

Graboski and McCormick[17] have summarized several experimental studies of biodiesel characteristics like cetane number for biodiesel which equal 45.8-56.9 for soybean oil methyl esters, in comparison the cetane number for petroleum diesel ranges from 40-52.

In this research, some mechanical, optical, miscellaneous and thermal properties for the samples estimated were determined, to know which of them are best to employ and especially at a slight occurred in gas oil and diesel in fuel stations.

Experimental Part

A- ***Instruments***: The employed instruments are:-

1) Digital balance (Sartorius, Bp- 2015-Germany).
2) Water bath, (W 350-Germany).
3) Refrectrometr, (Atago 1T- Japan).
4) Furnace, (mke- Pe 100 – Canada).

B-*Materials and Procedure:*

Five samples were studied, according to table(2):

No.	Sample
1	Gas oil
2	Gas oil + kerosene
3	Gas oil + kerosene + water
4	diesel
5	Lubricant oil for car's engine + kerosene + low amount from water
6	(1:4) Lubricant oil for car's engine + kerosene
7	(2:3) Lubricant oil for car's engine + kerosene
8	(3:2) Lubricant oil for car's engine + kerosene

Samples (1& 4) were got from fuel stations, samples (6-8) were prepared in laboratory (because these sample were prepared by criers, but other samples were got from criers.

The some mechanical, optical, miscellaneous and thermal properties were determined as density (d), specific gravity (Sp. gr.), thermal expansion coefficient (α), aniline point (A.P), diesel index (D.I) ,refractive index (R.I), heat of combustion (gross calorific value) (Q), heat of Latent (L) and the percentage of hydrogen (%H).

***** The mechanical properties***, density was measured by peknometer method, and by following equation [2] :

$$d = \frac{(m_t - m_o)}{(m_c - m_o)} \times \frac{\rho}{1000} \qquad \text{............(1)}$$

where:

d= The density of sample, in (gm/mL) at test temperature t_t.
ρ = The density of water, in (kg/m^3) at test temperature t_t.
m_o= The apparent mass in air (g) of the empty pyknometer.
m_c= The apparent mass in air (g) of the pyknometer filled with water of calibration temperature t_c.
m_t= The apparent mass in air (g) of the pyknometer filled with liquid under test at temperature t_t.

**The specific gravity was calculated by[18,19]:

$$Sp.gr. = \frac{d_{sample}}{d_{water}} \qquad at (15 \pm 1)^\circ C \qquad \text{................(2)}$$

Density and specific gravity are extensively used, but the industry generally prefers the (API) gravity. This property was determined by American Petroleum Institute of the following equation [20, 21]:

$$API\ Scale = \frac{141.5}{Sp.gr.(15^\circ C)} - 131.5 \qquad \text{.............(3)}$$

From the density at 25, 35, 45 and 55 °C can be calculated the coefficient of expansion (α) by [18]:

$$\frac{1}{d} = \frac{\alpha}{d_o} \times t + \frac{1}{d_o} \qquad ....(4)$$

where:

d_o = is the density at 0 °C.

α = thermal expansion coefficient .

t= temperatures 25, 35, 45 and 55 °C.

d= density of sample in different temperatures.

*****The miscellaneous properties*** as A.P and D.I were determined, the A.P was determined by mixing the certain volume of sample with same volume of aniline and determined the average of miscible(by heating) and immiscible (by cooling) temperatures in degree (°C) after that it converted in Fahrenheit temperature(°F) to determined the amount of aromatic compound, and calculated the D.I by next equation [2,19]:

$$Diesel\ index\ (D.I) = \frac{A.P\ (^{o}F) \times API}{100} \qquad ....(5)$$

*****The optical property***, refractive index was found by Abbi refractometer which regard as indicate of light-colored liquid petroleum products[22].

*****The thermal properties***, heat of combustion (gross calorific value) (Q) and heat of Latent (L) were calculated by next equations[23]:

$$Q = 12400 - (2100 \times (Sp.gr)^2) \qquad (\text{at } 15\ ^{o}\text{C}(60\ ^{o}\text{F})) \qquad ....(6)$$

$$L = \frac{1}{Sp.gr}\ x\ (110.9 - 0.09t) \qquad (at\ \ t = 60^{o}\ F) \qquad ....(7)$$

****The hydrogen content (%H)*** was calculated by following equation[24]:

[

$$\%H = 26 - (15\ x\ Sp.gr.) \qquad (\text{at } 15\ ^{o}\text{C}(60\ ^{o}\text{F})) \qquad ....(8)$$

*****The % Ash*** was measured by following equation [19]:

$$\%\ Ash = \frac{W_{sample\ after\ burn}\ (g)}{W_{sample\ before\ burn}\ (g)} \times 100 \qquad ....(9)$$

Results and Discussion

Table(3): Some mechanical properties (d, Sp.gr & API) for studied samples at ($t = 15 \pm 1\,^{o}C$)

The Samples	Density (g/ mL)	Specific gravity (Sp. gr)	API
1	0.765	0.758	55.175
2	0.468	0.464	173.391
3	1.623	1.607	-43.453
4	0.795	0.787	48.136
5	0.827	0.818	41.377
6	0.788	0.780	49.863
7	0.798	0.789	47.636
8	0.802	0.794	46.664

*Density (g/mL) of D.W = 1.0105 at 15 ^{o}C

From the results in table (3), which display that:

Sp.gr.(2) < Sp.gr.(1) < Sp.gr.(6) < Sp.gr.(4) < Sp.gr.(7) < Sp.gr.(8) < Sp.gr.(5) < Sp.gr.(3)
.

Sample (3) was a higher compared with other samples, that beyond to contain it a high amount of water(high density).

But the Sp.gr for sample (2) was low compared with other samples, that beyond to contain it a high amount of kerosene (low density and Sp.gr.).

The other values may be less from the permanent range(0.82- 0.84 Max.) [2,19] that beyond to the method of storage and additions which may be reasonable to Iraq's weather or cheating processes during littleness in local market.

The values of API for all samples were different about the standard range (39.72 Max.)[2], that beyond to the same reason.

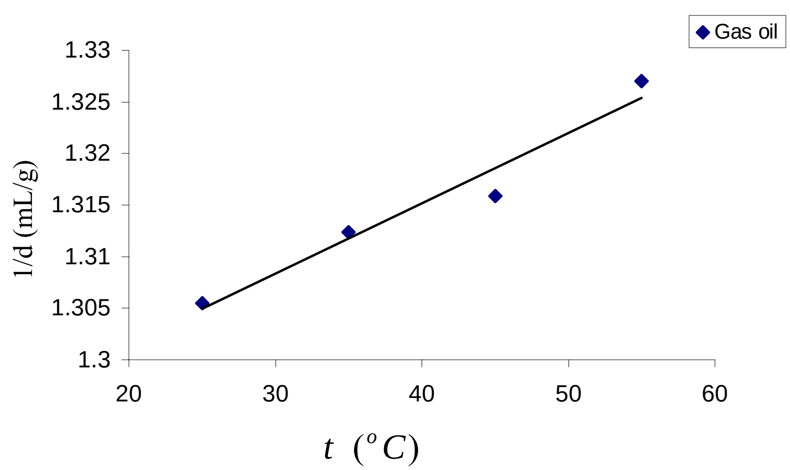


Fig.(1): The relation between $\frac{1}{density}$ versus temperature for the sample (1)

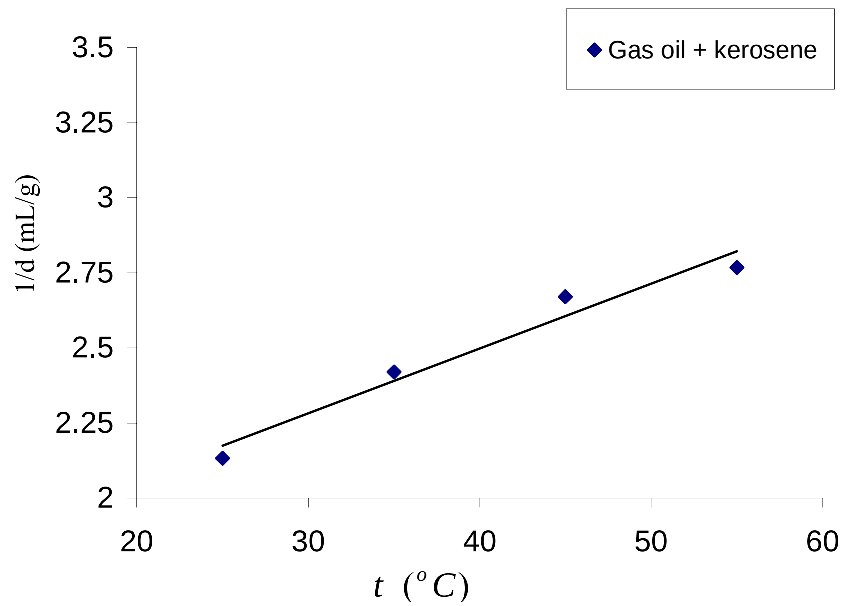


Fig.(2): The relation between $\frac{1}{density}$ versus temperature for the sample (2)

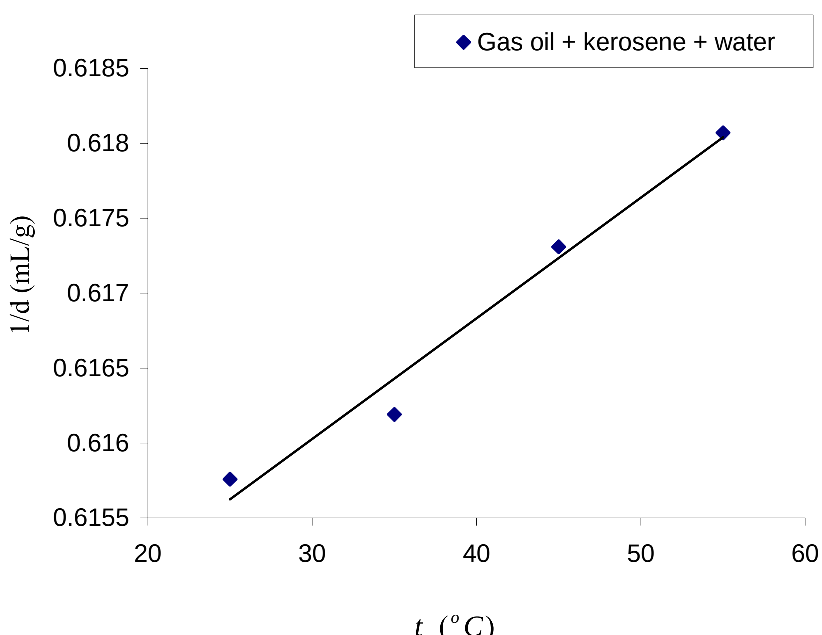


Fig.(3): The relation between $\frac{1}{density}$ versus temperature for the sample (3).

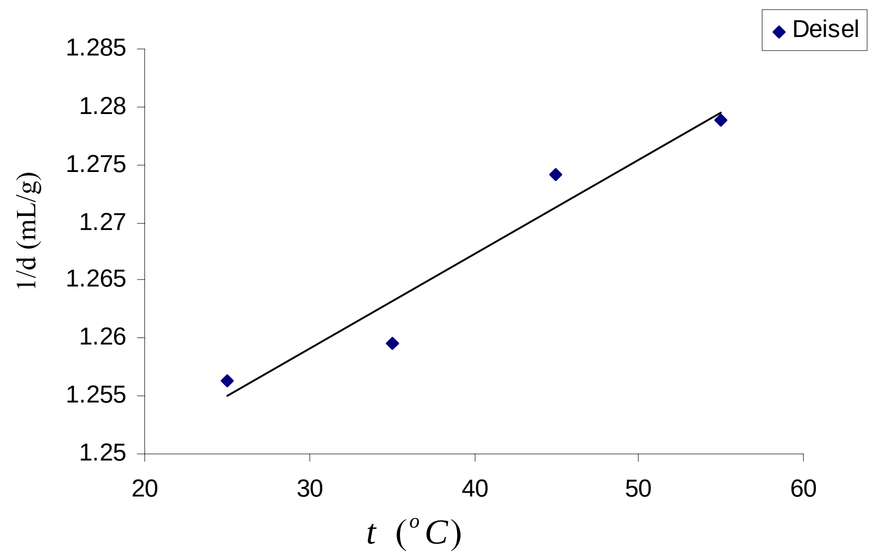


Fig.(4): The relation between $\frac{1}{density}$ versus temperature for the sample (4).

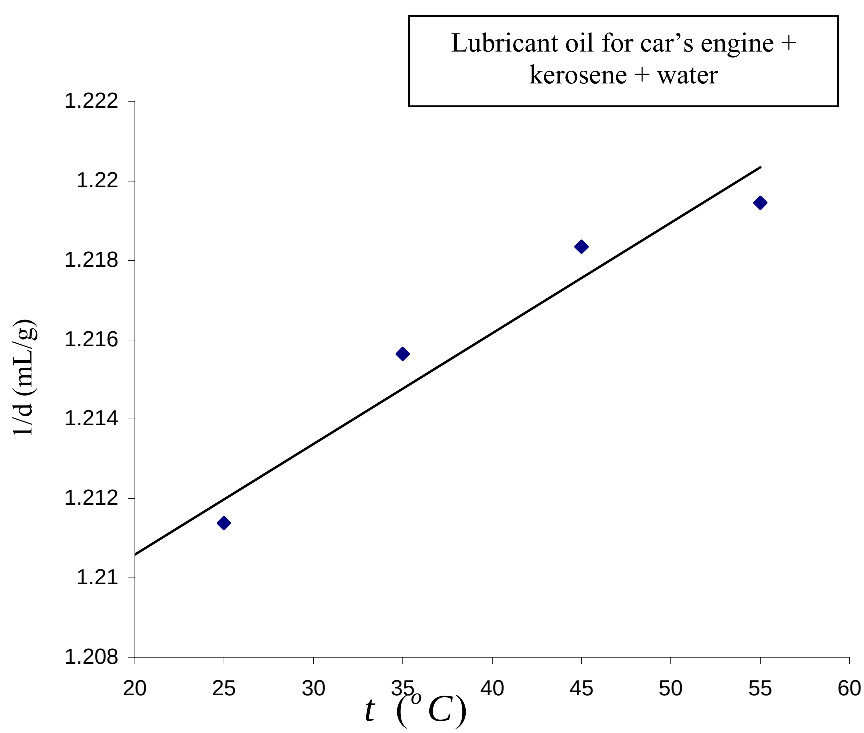


Fig.(5): The relation between $\frac{1}{density}$ versus temperature for the sample (5).

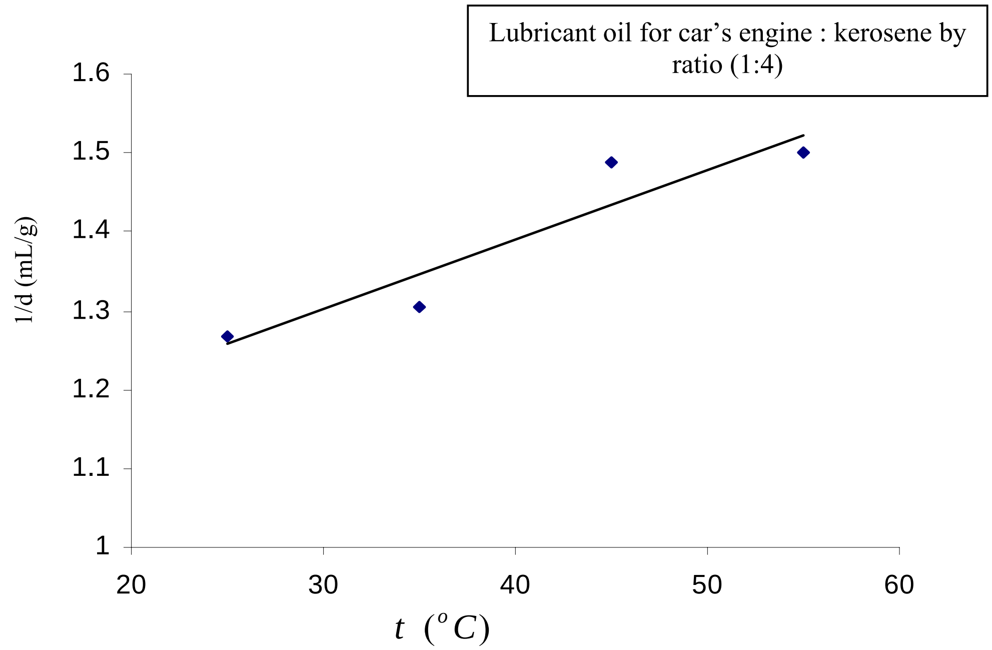


Fig.(6): The relation between $\frac{1}{density}$ versus temperature for the sample (6).

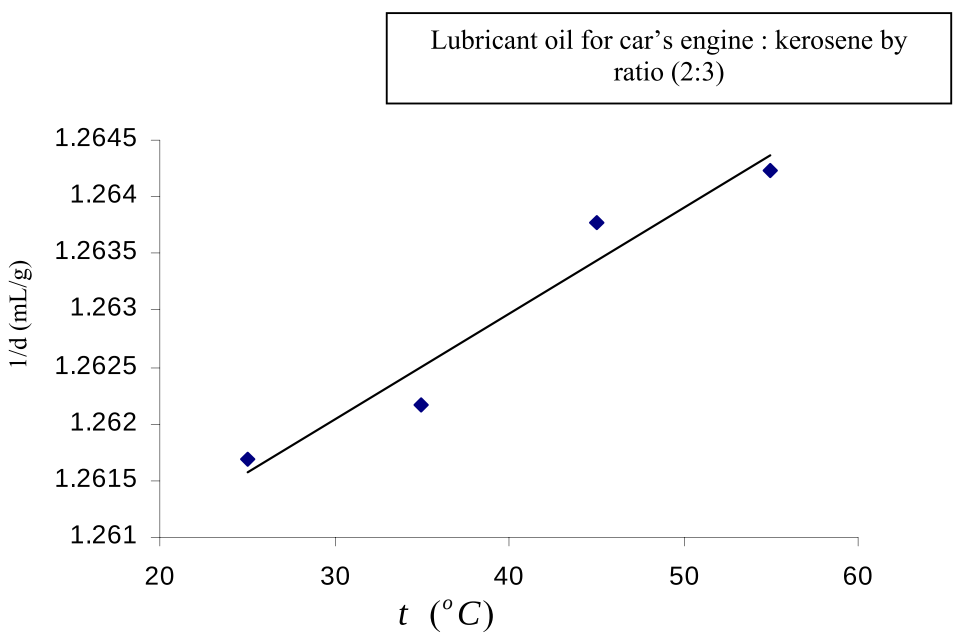


Fig.(7): The relation between $\frac{1}{density}$ versus temperature for the sample (7).

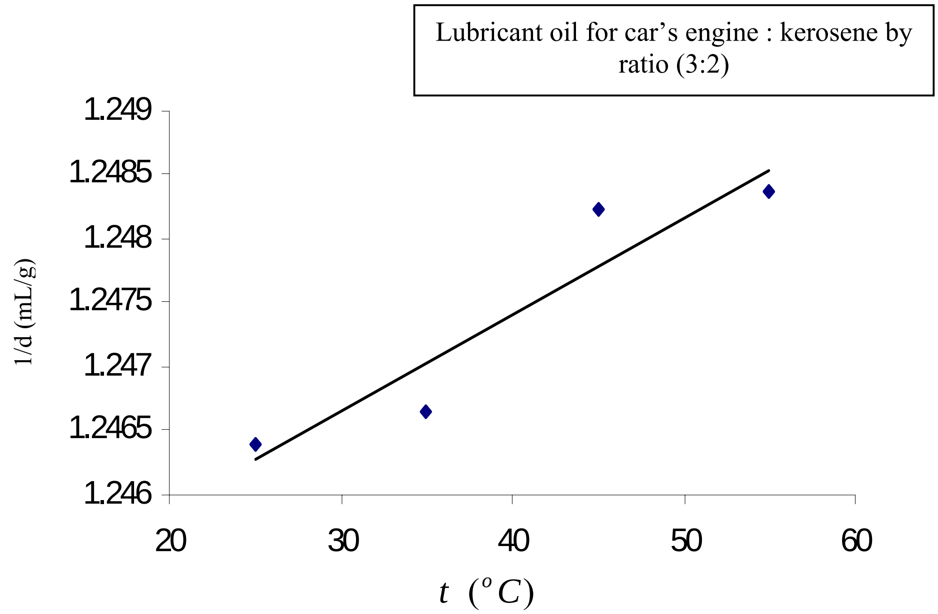


Fig.(8): The relation between $\frac{1}{density}$ versus temperature for the sample (8).

Table (4): The values of thermal expansion coefficient (α) for the study samples.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
(α) deg^{-1}	0.000543	0.00963	0.000130	0.000647	0.000249	0.007849	0.0003201	0.00005624

From figures (1,2,3,4,5,6,7 and 8) were found to calculate the values of thermal expansion coefficient (α) in table (4).
Such as:

(α)2 > (α)6 > (α)4 > (α) 1> (α)7 (α)5 > (α)3> (α)8.

Sample(2) is more large compared with other samples, to contain it high amount from kerosene which have low boiling point (150-250) ^{o}C compared with gas oil, diesel and lubricating oil[25].

Sample (8) is smallest values, that beyond to dissociate it (low stable) in storage.

Table (5): The miscellaneous properties as A.P and D.I

	1	2	3	4	5	6	7	8
Aniline Point (^oF)	116.06	123.35	133.70	114.35	73.40	78.80	97.70	100.4
Diesel index	64.33	213.84	-58.09	55.04	30.36	39.292	46.540	46.85

Results from table (5) show that the values of A.P may be:

A.P (5) <A.P (6) < A.P (7) < A.P (8) < A.P (4) < A.P (1) < A.P (2) < A.P (3)

That occurred to each samples (4 and 1) was had the best degree of ignition, and contained the more quantum from Aromatic compounds(19).

The values of diesel index due to :

D.I (2) > D.I (1) > D.I (4) > D.I (8) > D.I (7) > D.I (6) > D.I (5) > D.I (3)

That occurred to Sample (2) was made the larger value; that beyond to contain it a high amount from kerosene, which decreased the (Sp.gr.) of it.

But sample(3)and (5) were made the small values, that beyond to contain them a water which increased the (Sp. gr.) of them.

Samples (1,2 and 4) were had the permanent value (D.I > 53)(19).

Table (6): The optical properties (refractive index) for studied sample, kerosene, Lubricant oil for car's engine and water at $t = 15 \pm 1$ C°

Samples	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Kerosene**	**Water**	**Lubricant oil for car's engine**
R.I	1.457238	1.449039	1.447039	1.459040	1.461039	1.449539	1.459339	1.467839	1.436240	1.332840	1.4730405

The values of R.I were made as:

R.I (3) < R.I (2) < R.I (6) < R.I (1) < R.I (4) < R.I (7) < R.I (5) < R.I (8).

The value of R.I for sample (8) was have a larger compared with other samples, to contain it a high amount of lubricant oil (R.I for lubricant oil = 1.4730405).

But sample (3) was had the smallest value that beyond to contain it water (R.I for water =1.332840).

Sample(4) was more than sample (1), that beyond to contain it a large number of carbon atoms[26].

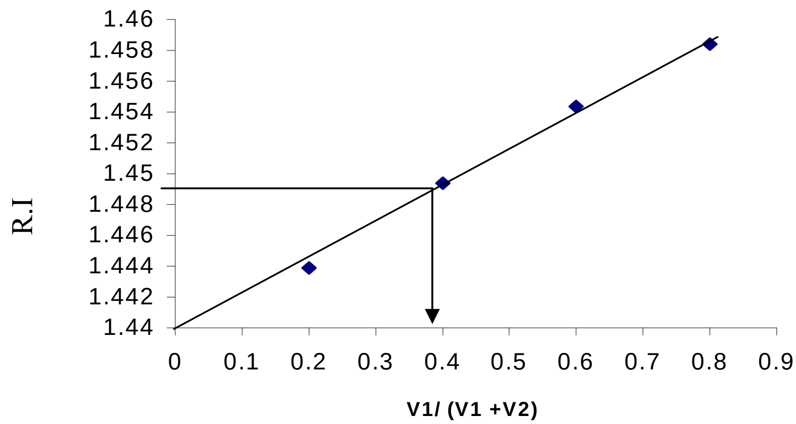


Fig. (9): The calibration curve for standard solution of gas oil with kerosene at $t = 15 \pm 1\,^oC$

When: V_1= gas oil, V_2= kerosene, (V_1+V_2)= 5mL

From Fig. (9) can be determined the ratio between gas oil and kerosene in sample (2) by following:

$$0.39 = \frac{V_1}{V_1+V_2} \Rightarrow 0.39 = \frac{V_1}{5} \Rightarrow V_1 = 1.95$$

$$\therefore V_2 = 5 - 1.95 = 3.05$$

$$\therefore gas\ oil : kerosene \cong 1:1.5$$

Table(7): The values of thermal properties (L, Q) and %H at ($t = 15\,^oC$, $60\,^oF$)

No. of samples	Q Kcal.Kg^{-1}	L Btu. Pound^{-1}	%H
1	11193.415	139.182	14.630
2	11947.683	227.321	19.038
3	6976.182	65.646	1.893
4	11097.010	133.934	14.184
5	10993.052	128.891	13.722
6	11121.704	135.221	14.297
7	11089.721	133.561	14.151
8	11075.384	132.836	14.086

Btu[12] :Britain temperature unit = 778 ft. Ib.

According to the results in table (7), the %H for all samples were without the standard range (13.47 and 13.70) [19] that beyond additives which may be reasonable to Iraq's weather or cheating processes during littleness in local market.

All values of heats of combustion (Q) for samples were fixed within standard range[19] (Q > 10550) Kcal. Kg^{-1} except sample (3), due to its high sp. gr[19] (contain water).

The heats of latent for all samples were fixed with the standard range [19](L > 126.347) Btu. $Pound^{-1}$ except sample (3) due to the same reason.

Table (8): The values of basicity and acidity for the studied samples at ($t = 30\,^{o}C$).

No. of samples	Basicity M	Acidity M
1	-	0.018
2	-	0.008
3	-	0.012
4	-	0.010
5	-	0.010
6	-	0.060
7	-	0.040
8	-	0.020

All values of acidity for studied samples were smaller, that benefit to prevent the corrosion processes in the car's engine which refer to find or don't find the trace amount of sulfur compounds in all samples.

Table (9): The values of percentage for %Ash of studied samples.

No. of samples	1	2	3	4	5	6	7	**8**
%Ash	0.207	0.668	0.975	0.860	0.900	6.315	17.681	26.607

All values were larger than standard range (0.01 % Max)[2], that beyond to additives, moving and storage, all that reasons would caused the pollution of them.

The %Ash values for 6,7,8 were very high that due to presence of higher amount of inorganic metal like (Ni, Zn ….etc.) [9, 19] during separation and purification processes in refineries.

Conclusions:

From this studied that show the addition of kerosene to gas oil may be good the storage property, so the sample (2) is making high value of thermal expansion compared with other samples.

The refractive index (R.I) is a very easy and simple method to know which of them (samples) are excellent or no, because R.I value is know for samples now.

The ratio of mixing in sample (2) may be: Gas oil : kerosene equal 1 :1.5.

In sprit of, the values of Sp. Gr of samples6,7 &8 were occurred in standard range[19], but the amount of %Ash may be very very high that caused the damage of car's engine in the little time.

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