Study the Effect of Friendly Environmental Materials Addition on Viscosity Index and Pour Point of Engine Diesel Lubricating Oil

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Abstract

In this work, the effect adding of some vegetable oils to mineral oil on physical properties such as viscosity and pour point of mineral lubricating oil was studied. Some vegetable oils, like corn oil and castor oil were used. Engine lubricating oil (si-cf4 diesel oil) that produced in AL-Doura refinery was selected and used in this study. Viscosity and pour point measurements were tested by viscometer and pour point tester respectively. Deferent mixtures of castor oil and corn oil were prepared with mixing ratios ranging from (0-100)% at 80°C added to the Iraqi motor lubricating oil with a percentage ratio in the range of (0-6) % and the best results was obtained at percentage ratio of 6% and study the viscosity index and pour point of the resulting lubricant oil. It was found that the addition of the of vegetable oil gave lubrication oil has a viscosity index ranging (106-115) and pour point ranging (-14--18)°C. It was found that the effect of addition of corn and castor oil mixture to mineral oil was varied according to the ratio of that oils.
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Keywords: Engine oils, Vegetable oils, additives, Viscosity Index.

Introduction

Lubricating oils are produced from the vacuum distillation of crude oil, this process gives a wide range of lubrication oils from which the engine oils are manufactured [1], the function of lubricants is to reduce friction and wear which results from the formation of a lubricant film separating the rubbing surfaces , reduce energy and fuel consumption , maintain equipment from corrosion by forming a lubricating layer that covers the surface of the engine metal and can also contribute to reducing operating temperatures [2]. Chemical additives are used and mixed with base oils for the purpose of improving their performance such as antioxidant additives, detergent additives, antifoaming additives, pour point and viscosity index improvers [3]. Without additives, the base oils are weakly in its properties, the performance of a lubricant based on the base oil, additives and formulation [4].

The conventional additives include elements such as phosphorus , sulfur and zinc, additives that include sulfur are the first famous additives in lubricating oils to improve physical properties oils. In the last years, alcohols, amines and esters have been used as additives, forming a molecular layer related to the surface by physical or chemical adsorption [5].

The important properties for favorite engine performance are low viscosity and suitable flow in the temperature of use [1,6].

Now the world is turning to environmentally friendly additives which have the ability to renew and have the capacity to self-degradability, vegetable oils are one of the most important additives [5].

Vegetable oils have polar groups that have the ability to adhere to the surfaces of metals, which gives a touching layer that provides good thickness for the lubrication process. Vegetable oils have a high viscosity factor due to the strength of the attraction between the molecules provided by the double bonds found in the unsaturated fatty acids[3], they also have other advantages that give them desirable properties such as low volatilization because of the high molecular weight of the triglycerides, high flash of oils gave them the stability and also provide enough interaction to form chemical bonds with other polymer chains in oil [5,7,8]. One of the important vegetable oils used in this field are castor and corn oil, which have some of the desired qualities in the field of oil improvement. It is known that the high viscosity index of vegetable oils increases the viscosity values of the mineral oil. The chemical composition of the additives plays a major role in determining the efficiency [3]. The current research studied the effect of the addition of corn and castor oils to mineral lubrication oil through viscosity and pour point measurements.

Experimental Work
a-Materials

1-Iraqi engine oil produced by Al–Doura refinery (diesel oil), its physical and chemical properties has been tested in Al–Doura refinery, as shown in Table (1).

Table (1)
Properties of engine oil (si-cf4 diesel oil) product and tested in AL-Doura Refinery with standard tests.

Property	Diesel oil	Testing method ASTM (American Society for Testing Materials)
Specific gravity at 15.6°c	0.885	D941-5
Viscosity at 40°c,cst	156.91	D445
Viscosity at 100°c,cst	16.160	D445
Viscosity Index	107.43	D2270-93
Flash point,°c	210	D92
Pour point,°c	-13	D97
Total acid number mg KOH/g	0.00	D974
Ash content, wt%	0.00	D482

2-Vegetable oils of corn oil (Afia International –Savola foods/KSA) and castor oil (India Mom company), their physical and chemical properties have been shown in Table (2).

Table (2)
Properties of corn and castor oils with standard test.

Property	Corn oil	Castor oil	Testing method ASTM
Specific gravity at 15.6°c	0.9152	0.9651	D941-5
Viscosity at 40°c, cst	32.428	251.75	D445
Viscosity at 100°c	7.756	19.433	D445
Viscosity Index	222.619	87.76	D2270-93
Pour point, °c	-15	-21	D97
Flash point, °c	230	229	D92
Total acid number mgKOH/g	0.00	0.00	D974

b-Equipments:

1. Viscometer to measure Kinematic viscosity (HVV481/UBBELOHD Herzo/ Germany Viscometer.
2. Pour point measuring Instrument (Koehler Instrument/ USA).

c-Experimental procedure

1-Preparation a vegetable oil mixture:

1.1-Corn and castor oils were mixed at 50:50% Ratio at 80°C for 90 min. with stirring at 600 cycle /min , using magnetic stirrer.

1.2-The above mixture was added to 100 gm of engine oil at (0-6)% ratio with continuous stirring (600 cycle /min.), 80°C for 90 min.

1.3 -Corn and castor oils were blended within the range of (0-100) % at 80°C and for 90 min. with continuous stirring to insure a complete blending by using a magnetic stirrer at a speed 600 cycle/min.

1.4-100 gm of engine oil (diesel oil–sicf4) added to the mixture of vegetable oils at 6%, 80°C for 90 min. with stirring.

d-Measurement the resulting blend oil sample according the following tests:

1-Pour point/ ASTM(D97), as follows:

50 ml of the sample is placed in glass test tube and placed in the bath of the pour point device. Exposure the sample to a thermal

program, observe the flow of the oil inside the test tube by lifting it diagonally ,then returned to the bath and repeat the process until the oil stopped the flow, record the temperature and this is the pour point of the oil.

2-Measure the kinematic viscosity at 40°C and 100°C according to ASTM (D 445), as follows:

20 ml of the sample is placed in appropriate viscometer which is immersed in the oil bath of the viscosity device. Then some required information for the device are inserted such as value of constant of the viscometer and the temperature required for the test. The device is turned on and recorded the reading which is appear in the screen of the device.

3-Viscosity index measurement accordingly, as ASTM(D2270) by using (Dean& Devis) equations and by the following methods:

First method: specialization for the oils that had viscosity index less or equal 100, according to the following steps:

1.If the kinematic viscosity of the oil at 100°C is about (2-70 cst), then the reciprocity series of (L &H) in (Dean & Devis) tables would be obtained, whereas viscosity index (VI) can be calculated by using Eq.(1).

$$VI=[(L-U)/(L-H)]*100 \quad ....(1)$$

Where, H is the kinematic viscosity at 40°C to standard oil of 100 VI, L is the kinematic viscosity at 40°C to standard oil of 0 VI and U is the kinematic viscosity at 40°C of the oil whose VI is reclaimed.

2.If the kinematic viscosity of the oil at 100°C is greater than (70 cSt), the values of L&H can be calculated by using Eqs.(2) & (3), as follow:

$$L = 0.8353Y^2 + 14.67Y - 216 \quad ....(2)$$
$$H = 0.1684Y^2 + 11.85Y - 97 \quad ....(3)$$

Where, Y represents the kinematic viscosity of the oil at 100°C, after that, the values of U,L and H would be apply in (Dean & Devis) equation to obtained the VI of the repairing samples of this research.

Second method: Involved the oils that have VI greater or equal to 100,as the following steps:

1. If the kinematic viscosity of the oil at 100°C is about (2-70 cst), then the reciprocity series of (H) from (Dean & Devis) tables would be obtained.
2. If the kinematic viscosity of the oil at 100°C is greater than (70 cSt), the value of (H) can be calculated by using Eq.(3). Then Eqs.(4)&(5) would be used to find the VI value, as follow:

$$N = (logH - logU)/logY \quad ....(4)$$
$$VI = [(antilogN) - 1/(0.00715)] + 100 \quad ....(5)[3]$$

Results and discussion

In this study the effect of addition of mixed vegetable oils (corn oil and castor oil) was studied, In the first step, mixture of castor and corn oils was prepared at different percentage to ensure good mixing. The second step involved the addition of the mixture of vegetable oils to the engine oil in the reactor at 80°C, 600 rpm for 90 min. Fig.(1).

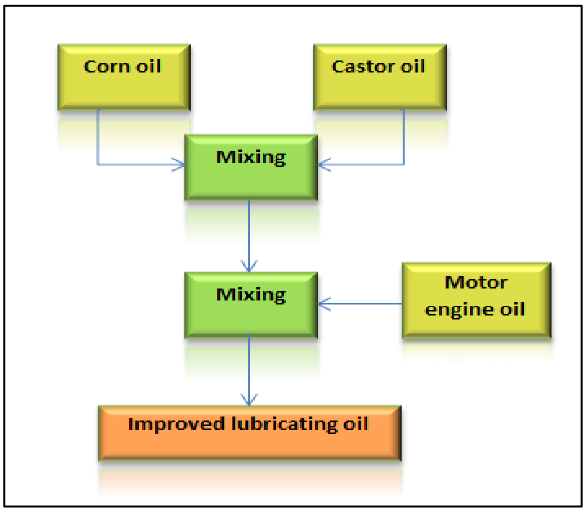

Fig.(1): Diagram of the preparation of improved lubricating oil.

In general, the addition of vegetable oils to the mineral lubricating oil might has an effect on the physical properties of it such as viscosity and pour point because the long chain of molecules that found in the vegetable oil. The degree of the effect of addition depend on the quantity and quality of the vegetable oil which is differ in the type and percentage of fatty acid compositions as shown in Table (3).

Table (3)
Fatty acids in corn and castor oils with their percentage.

Fatty acids (%)	Corn oil	Castor oil
Palmitic acid C16	3.18	9.3
Stearic acid C18	1.8	9.3
Total saturated fatty acids	4.99	18.6
Oleic acid C18:1	35.82	7.7
Ricinoleic acid C18:1	-	65.9
Linoleic acid C18:2	56.8	6.6
Linolenic acid C18:3	2.4	-
Total unsaturated fatty acids	95.02	80

Viscosity index

Viscosity index is one of the most important properties of lubricating oil which is reflect the range of the effect of viscosity of lubricating oil upon the change in temperature.

The lubricating oil which has high viscosity index is prefer because it has excellent efficiency of lubrication and low consumption in use it at opposite of oil which has low viscosity index [9]. A mixture of corn and castor oils was prepared at ratio (50:50) and blended with engine oil that produced at AL-Doura refinery at range of concentration (0-6) % and record viscosity at 40, 100°C and viscosity index as shown in the Table (4) and Fig.(2).

Table (4)
Viscosity index and pour point of lubricating prepared oil.

Sample No.	concentration of additive 50 :50 (corn: castor oil)%	Viscosity at 40°c	Viscosity at 100°c	Viscosity Index	Pour point,°c
A	0	156.91	16.16	107.43	-13
B	2	154.53	16.09	108.28	-14
C	4	152.29	15.98	108.97	-15
D	6	149.20	15.81	109.72	-16

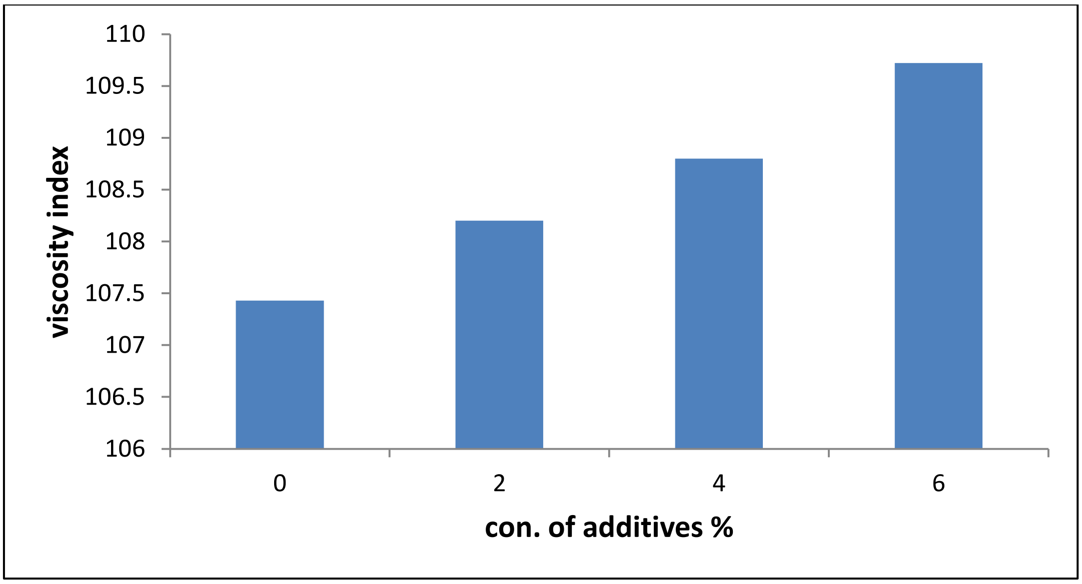

Fig.(2): Relation between viscosity index and con. of additives %.

From Fig.(2), it was found that the higher viscosity index (109.72) was obtained from 6% addition of the mixture. So, it was selected the concentration of addition at 6% of mixed corn and castor oils and blended with lubricating engine oil and change the ratio of corn and castor oils that added and the data presented are summarized in Table (5) which illustrates that the viscosity at 40,100°C, viscosity index and pour point of the blended samples.

Table (5)
Viscosity index and pour point of prepared lubricating oil (Engine oil + 6% additives).

Sample No.	Sample Composition	Viscosity at 40°c	Viscosity at 100°c	Viscosity Index	Pour point,°c
1	Engine oil without Vegetable additives	156.91	16.16	107.43	-13
2	Engine oil with 100% corn oil	144.07	15.92	115.45	-14
3	Engine oil with 90% corn :10% castor	139.45	15.54	115.37	-14
4	Engine oil with 70% corn :30% castor	145.22	15.67	111.48	-15
5	Engine oil with 50% corn :50% castor	149.20	15.81	109.72	-16
6	Engine oil with 30% corn :70% castor	155.35	16.01	106.96	-17
7	Engine oil with 10% corn :90% castor	167.15	16.16	99.74	-18
8	Engine oil with 100% castor oil	179	16.83	99.10	-18

The results were reported in the Fig.(3) which represent that the increasing in the viscosity index was observed with increasing corn oil content and this may be because the high unsaturated fatty acids content (95%) in the Table (3), which causes to increase the attraction forces between molecules and result in increasing viscosity index value, at other hand, in spite of the high unsaturated fatty acids content of castor oil (80%) in the Table (3) and this may refer to the hydroxyl group that found in ricinc oleic acid which is caused too far away the molecular chains from other and decrease the attraction forces and last decreasing of the viscosity index value [10].

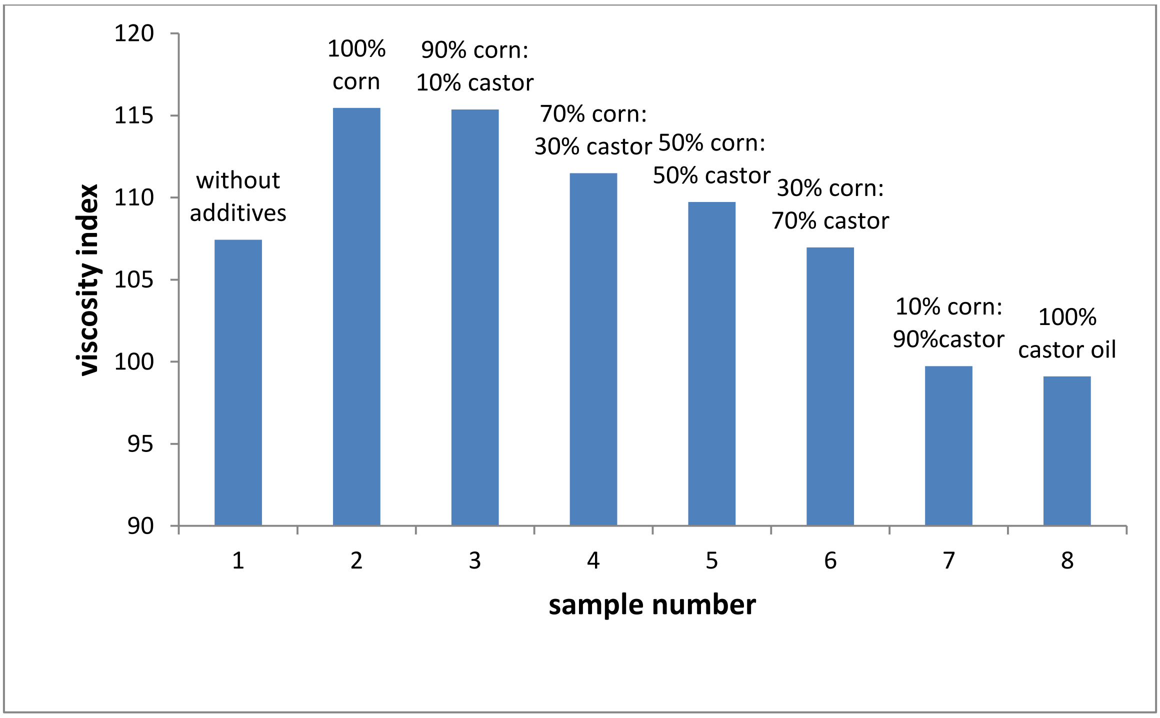

Fig.(3): Relation between viscosity index and sample number.

Pour point

The pour point of oil is good indicator of fluidity at low temperatures at which the wax molecules starts to separate from the oil that found in it formation net of crystals that causes decrease the fluidity of the oil. In general The addition of vegetable oil to the mineral oil result in decreasing the pour point of it because the vegetable oil form macro structure through triglyceride backbone which is easy flow of of the lubricating oil because it has unsaturated bond that can be caused more bent to the distance between the molecules , and delay the growth of crystals.[11] A mixture of vegetable oils which contain 50:50 corn and castor oil and added it to the engine oil at (0-6)% concentration and study the pour point as shown in Table (5) and Fig.(4).

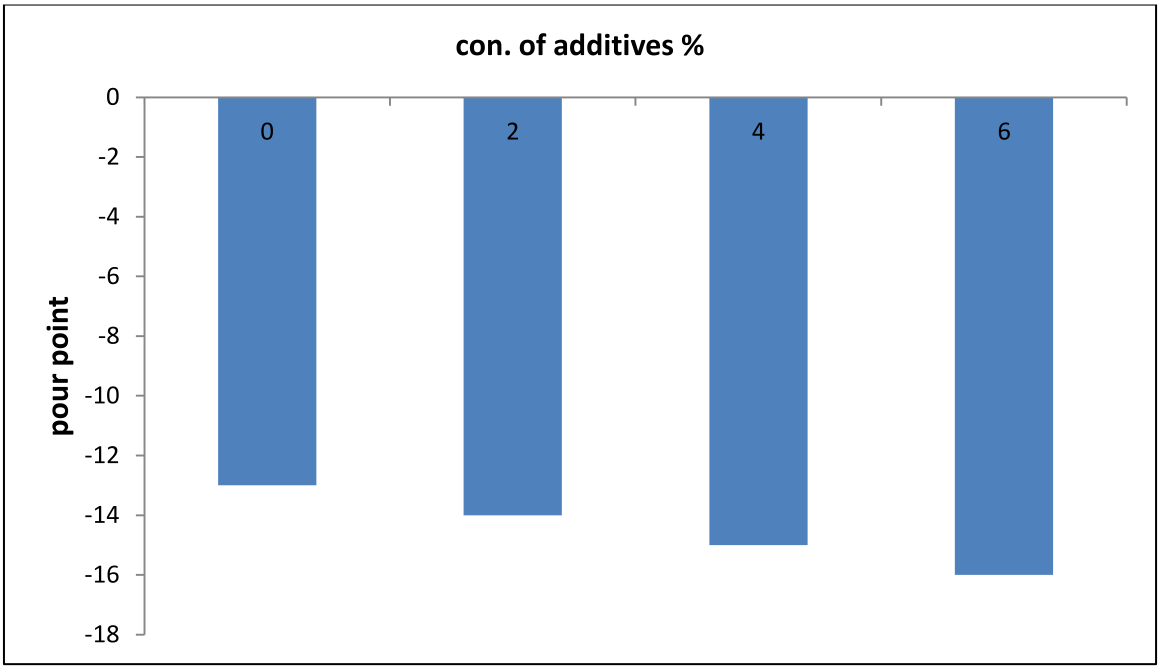

Fig.(4): Relation between pour point and con. of additives%.

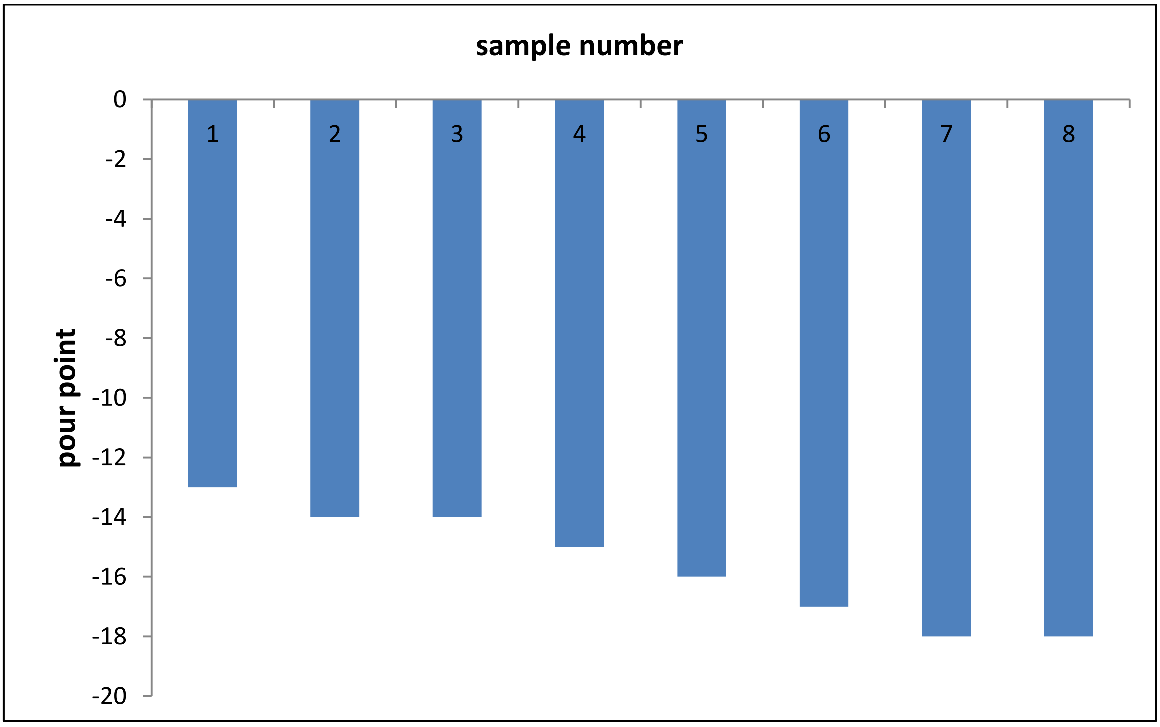

Fig.(5): Relation between pour point and sample number.

Fig.(5) illustrate that the lower pour point was obtained from addition of 6% of the blend vegetable oil, thus we fixed the concentration of the addition of blend oils (6%) and change the type of the combined corn and castor oils.

Pour point results of improved lubricating oil in mixture quantity of corn and castor oil are shown in the Table (5) and Fig.(5) which shows that pour point decrease with increasing the amount of castor oil and that may be because the high saturation of the fatty acids that found in castor oil as compared to that found in corn oil as shown in Table (5)[12].

Conclusions

1. This study provided a clear effect of addition of some vegetable oils like corn oil and castor oil to the viscosity index and pour point of the mineral lubricating oil.
2. Viscosity index of mineral lubricating oil increases with increasing of corn oil content.
3. Pour point of mineral lubricating oil decreases with increasing of castor oil content.

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