Effect of Additives on the Performance of Bio-lubricant Base Oil Produced from *Colocynthis* Seeds Oil

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ABSTRACT

Bio-lubricants are gaining popularity and acceptance globally due to their sustainable and environmentally friendly properties; being derived from feed stocks from vegetable oils. Where the main drawback of vegetable oils is; its poor oxidation stability and low temperature performance. This study aimed to study the effect of additives (Hitech 723) on the performance of bio-lubricant base oil produced from *Colocynthis* seeds oil. Hitech 723 additive package with different doses (0.3 and 0.6 g/100g oil), and pour point dispersant (PPD) additive with different doses (0.12 and 0.24g/100g oil) were added. Some physicochemical properties were measured before and after blending with additives. The addition of additives improved the kinematic viscosities, viscosity index, density and pour point of the base oil. The results of this study demonstrate that blending the bio-base oil from *Colocynthis* seeds and additives provides a suitable alternative to diesel lubricants base oil.

Keywords: *Colocynthis* seeds oil, Lubricant, Additives

تأثير المحسنات علي اداء الزيت الأساسي المكون لمواد التشحيم الحيوية المستخلص من بذور زيت الحنظل (*Citrullus Colocynthis L.*)

الملخص □ □

مواد التشحيم الحيوية اكتسبت شعبية وقبول عالمي نسبة لخصائصها المستدامة والصديقة للبيئة. حيث ان للزيوت النباتية عيوب تتمثل في انخفاض معدل استقرار الأكسدة وانخفاض الأداء عند درجات الحرارة المنخفضة. تهدف هذه الدراسة لتحسين خواص الزيت الأساسي عن طريق مزجه مع بعض المحسنات, وقياس الخواص الفيزيوكيميائية قبل وبعد الاضافة. اضافة المحسنات حسنت اللزوجة الكينامتيكية، مؤشر اللزوجة، الكثافة ونقطة الانسكاب للزيت الأساسي. النتجة من هذه الدراسة اثبتت ان مزج الزيت المستخلص من بذور الحنظل مع حزم المحسنات يعطي بديلا مناسب لمواد التشحيم البترولية.

INTRODCUTION

Environmental pollution has negatively affected the life of both animals and human beings. Due to this considerable attention has been made to renewable resources and its production (biodiesel and lubricants precisely) in a way to control the current environmental issues. The use of renewable resources in industrial applications has been of interest in the governmental, commercial and more importantly consumer conscience. During the past few years the importance of environmentally friendly lubricants has been increasing rapidly which produced from vegetable oils (Karmakar *et al*., 2015), the toxicity issues of conventional and synthetic lubricants; lower viscosity, non-renewable petroleum resources as well as their rising cost related to a global shortage and their poor biodegradability led to renewed interest in the development of environmental friendly lubricant (Karmakar *et al.*, 2017; Gashaw and Lakachew, 2004).

Vegetable oils as one of the renewable feed stocks for some industrial applications and are in greater demand in critical areas requiring "total loss" or "once through" materials like two-cycle-engine oils, chain saw lubricants, hydraulic fluids, boat engines, tractors, agricultural equipment, metal working fluids, refrigeration oils, and so on (Gashaw and Lakachew, 2004 ; Erhan, 2005). Many global initiatives have been undertaken to increase the market share of environmentally friendly bio-based products such as biodiesel and bio lubricant. Lubricity/lubricant can be defined in many ways. "Lubricity is the ability of a liquid to provide hydrodynamic and/or boundary lubrication to prevent wear between two moving parts or the ability to reduce friction (Shugarman, 2006). Bio-based lubricants or bio-lubes, are made from a variety of vegetable oils also they are esters of heavy alcohols derived from vegetable oil based feedstock and have lubricating properties similar to those of mineral oil-based lubricants (Haycock and Caines, 2004; Karmakar and Ghosh, 2014; Knothe *et al.*, 2005; Shugarman, 2006).

The base oil that reported for biodiesel and lubricants are mainly prepared from four categories of feedstock: edible vegetable oils such as soybean and sunflower; inedible vegetable oils such as jatropha and algae; recycled oils and animal fats such as tallow and chicken. Moreover, indicated that at the present time, three-hundred and fifty sources of fats and vegetable oils are used for biodiesel preparation, and edible vegetable oils account for 95% of these sources. According to the UN Human Rights Council; the use of this feedstock is “a crime against humanity” because edible vegetable oils are some of the principal sources of human food (Sbihia *et al.*, 2018; Karmakar and Ghosh, 2014; Knothe *et al.*, 2005; Shugarman, 2006).

Vegetable oil based lubricants are natural, renewable, less toxic and easily biodegradable. In addition, they have a superior viscosity index, lubricity characteristics and solubilizing power for polar contaminants and additive molecules (Erhan, 2005). They show a much lower coefficient of friction, which can lead to reduced energy consumption for almost any part of the equipment in which they are used, also they have a specific functional attributes such as high viscosity index, good lubricity, superior anticorrosion properties, high flash point, high biodegradability, low aquatic toxicity, etc. Although bio-lubricants produced from vegetable oils which are costly and used to face humans needs, non-edible oils are cheap feedstock, readily available and doesn’t create a shortage of food for human consumption, this makes the non-edible oils such as jatropha, castor oil and *Colocynth* seeds oil. These advantages that made vegetable oils are now attention beside their physiochemical properties and environmentally acceptable.

Additives are widely used to improve the lubricant performance of base oil, on the other hand, additives are substances which improve the performance of lubricants, either by imparting new properties to a base oil or grease, or by enhancing the properties. Without additives, even the best base fluids are deficient in some features. The performance of a lubricant depends collectively on the base oil, additives and formulation (Hsien and Liew, 2015). This research aimed to study the enhancement of bio-lubricant from *Colocynth* seeds oil by blending with additives.

MATERIALS AND METHODS

Colocynthis seeds was obtained from north of Sudan, the seeds were cleaned and dried and then oil was extracted mechanically using oil extractor (TINYTECH RAJKOT INDIA). Oil content was determined according to American oil chemist society (AOCS) method (1985). Moisture content was carried out according to AOCS method (1993). Free fatty acid was carried out according to AOCS official method Ca 5a-40 (1997). Peroxide value was carried out according to AOCS official method (1973). Saponification value was carried out according to AOCS official method C.d. 3-25 (1973). Unsaponifiable matter was carried out according to AOCS official method Ca 6b-53 (1997).

Kinematic viscosity was carried out according to American Standard Testing Materials (ASTM) official method D-445. Viscosity index was carried out according to ASTM D-2270. Density was carried out according to ASTM D4052-96. Flash point was carried out according to ASTM D92-04. Pour point was carried out according to ASTM D97-04. Two types of additive packages were added to the base oil, Hitech 723 which represents anti-wear hydraulic additive package that contains a lot of inhibitors and pour point depressants (PPD) which is inhibiting the formation of crystal structure, both of them were added in specific recommended dose.

RESLUTS AND DISCUSSION

Table (1) presented some physiochemical properties of *Colocynthis* seeds oil. The oil content is 22.79% which agreed with the results obtained by Olaofe *et al.* (2012), Chan *et al.* (2018) and Igwenyi (2014). The moisture content is 0.16%, which agreed with the results reported by Sadou *et al.* (2007) and Igwenyi (2014). The free fatty acid (FFA) is 0.26, which agreed with results obtained by Olaofe *et al.* (2012), Chan *et al.* (2018) and Igwenyi (2014). While, the peroxide value is 3.35, also, agreed with results obtained by Chan *et al.* (2018), Bello and Makanju (2011) and Sadou *et al.* (2007). The saponification value of is 191.7, which agreed with the results obtained by Sadou *et al.* (2007), Olaofe *et al.* (2012), Chan *et al.* (2018) and Igwenyi (2014). Unsaponifable matter is 2.549 relatively higher than Gupta and Chakrabarty (1964) and agreed with results obtained by Bello and Makanju (2011) and Sadou *et al.* (2007).

Table (1): Physiochemical properties of *Colocynthis* seeds oil.

Test name	**Value**
Oil Content %	22.79
Moisture Content %	0.16
FFA%	0.26
Peroxide Value	3.35
Saponification Value (mgKOH/g)	191.7
Unsaponifiable Matter	2.549

Table (2) represents some chemical and performance properties of the base oil, mineral oil SN150 from FUCHS company, ASTM range and Urbain standard for neutral oil (N150). At 40°and 100°C the kinematic viscosity are 33.31 cSt and 7.875 cSt respectively. Compared to FUCHS Company (SN150) results showed that the kinematic viscosity of *Colocynthis* seed oil is higher than the mineral base oils SN150, also, higher than results obtained by AbdElrahman and Yassin (2009) and in the line of ASTM range. Moreover, this kinematic viscosity is closed to neutral oil 150N. The viscosity index is 221, which is higher than SN150 and AbdElrahman and Yassin (2009), and agreed with the ranges of ASTM and N150. The density at 35°C is 0.9122 which is relatively high compared to the result of SN150, N150 and ASTM. Density is represent an individual parameter in determination viscosity, high density indicate a good viscosity. The flash point is higher than SN150 and N150, also, agreed with ASTM requirement, which means safely enough for handling, transportation and shipping. The pour point of the *Colocynthis* seeds oil is -6°C, which is similar to N150 and relatively higher than SN150 mineral base oil and the range of ASTM. High pour point affects the usage of the base oil in cold area.

Table (2): Chemical and some performance properties

Test name	**Base oil**	**SN 150**	**N150**	**ASTM**
Kinematic viscosity at 40°C	33.31	29-37	38	29 - 37
Kinematic viscosity at 100°C	7.87	5-18	4.6 – 5.6	5.3 – 15.9
Viscosity index	221	106	100	97 min
Density at 35°C	0.9122	0.8614	0.875 at 15°C	0.877-0.884

Flash point	331.0	225	190 min	Above 200
Pour point	-6	-15	-6	-37 to -10

Note: min: minimum

Table (3) and Fig (1), (2), (3), and (4) shows the addition of additives Hitech 723 and PPD to the original base oil has relatively improved the kinematic viscosities, viscosity index, density and pour point of the oil, which could increase more by using a proper catalyst and use extra heat at mixing step. Vegetable oils generally have a low oxidation stability compared to mineral base oil, Hitech 723 package contains an oxidation inhibitors, Thus, addition Hitech 723 additive improve the oxidation stability of the base oil.

Table (3): Some properties of the oil after adding some additives

Type of additive	**Kinematic viscosity at 40°C**	**Kinematic viscosity at 100°C**	**Viscosity index**	**Density at 35°C**	**Pour point °C**
Hitech 723 (0.3g)	33.424	7.8822	220	0.9123	_
Hitech 723 (0.6g)	33.895	7.931	218	0.9127	_
PPD 0.12g	_	_	_	_	-9
PPD 0.24g	_	_	_	_	-12

Note: PPD: pour point dispersant additive

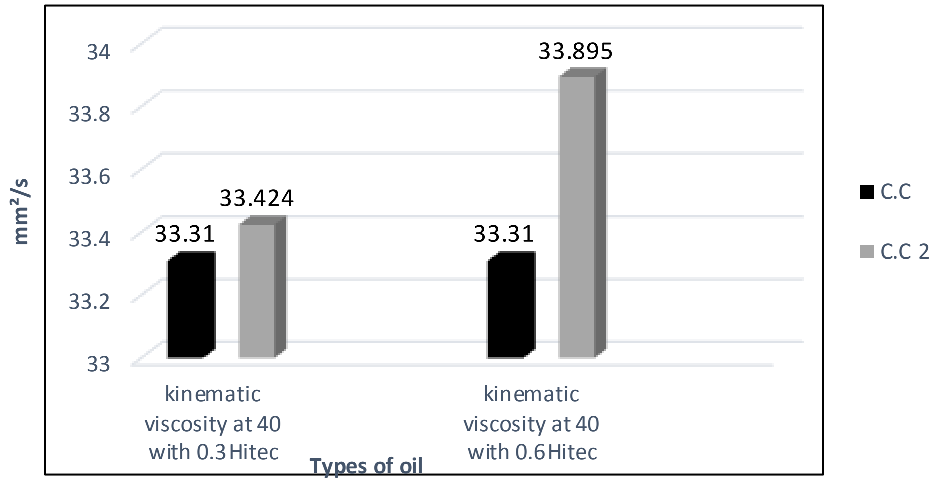


Figure (1): Kinematic viscosity at 40°C

Note: C.C: *Colocynthis* seed oil; C.C 2: *Colocynthis* seed oil blended with additive

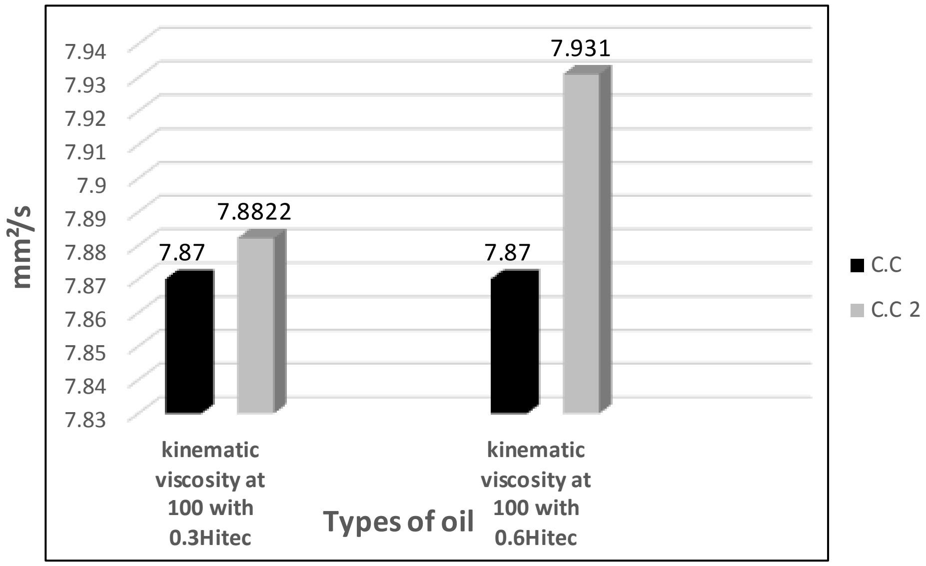
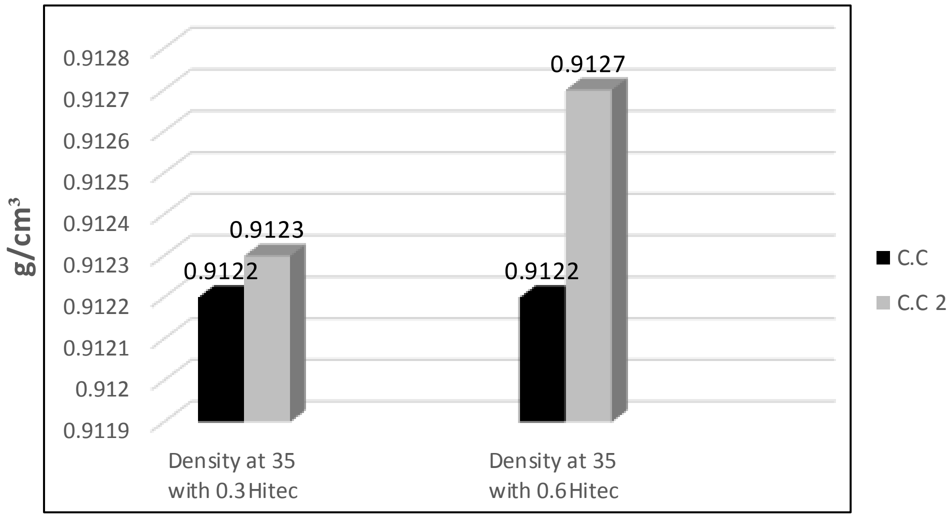


Figure (2): Kinematic viscosity at 100°C

Note: C.C: *Colocynthis* seed oil; C.C 2: *Colocynthis* seed oil blended with additive



Types of oil

Figure (3): Density at 35°C

Note: C.C: *Colocynthis* seed oil; C.C 2: *Colocynthis* seed oil blended with additive

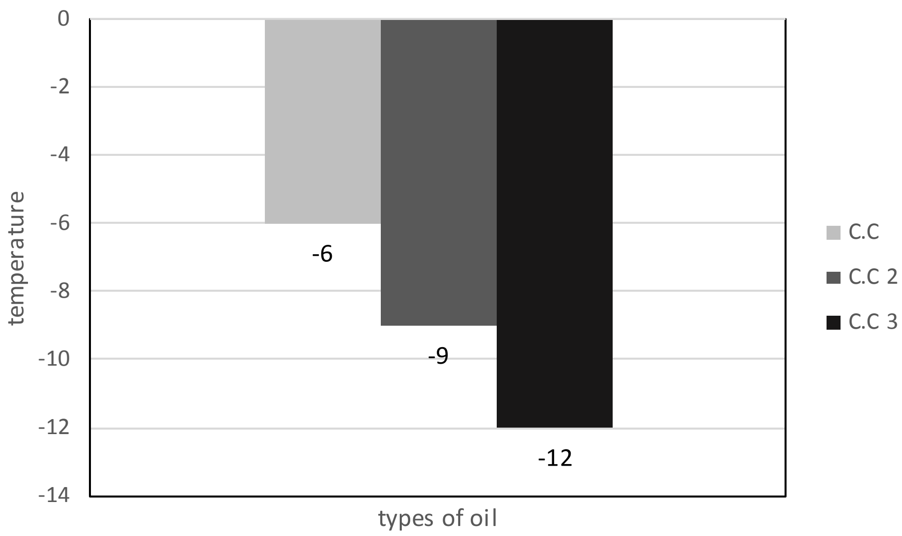


Figure (4): Pour point

Note: C.C: *Colocynthis* seed oil; PPD: pour point dispersant additive; C.C 2: *Colocynthis* seed oil with 0.12 PPD; C.C 3: *Colocynthis* seed oil with 0.24 PPD

CONCLUSIONS

The addition of additives affected the properties of the original base oil. The kinematic viscosity showed a good response with additive which is equivalent to mineral base oil, moreover, viscosity index is higher than mineral base oil, the high flash point indicated safely for handling, shipping. Also, pour point showed a positive decrease which may allow using the base oil in cold weather areas. The improved in the base oil properties after addition of additives lead to consider some other factors such as heat, catalyst, dose of additive … etc.

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