International Journal of Applied Sciences and Smart Technologies

Volume 4, Issue 2, pages 221 - 232

p-ISSN 2655-8564, e-ISSN 2685-9432

Comparative Study of Master Oil (MO) and Lophira Lanceolata (Ochnaceae) Oil (LLO) Lubricants in Sewing Machines

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(Received 15-09-2022; Revised 09-10-2022; Accepted 26-10-2022)

Abstract

In this paper the thermodynamic properties (Fire, Flash, Cloud, Pour points, and Volatility) of master oil (MO) and locally processed Lophira lanceolata oil (LLO) were determined using standard laboratory methods. The results show that LLO has lower volatility which means it can stay longer in moving parts of a machine than MO. Also, the results show that the flash and fire points of the lubricants lie within the maximum operating temperature range (<300 oC) of sewing machines. The high pour point (14 oC) and cloud point (23 oC) of LLO limit its use as a lubricant in low temperate regions of the world as opposed to -14 oC and -7 oC respectively for MO which has universal application. This implies LLO needs to be chemically blended with some additive agents that can lower its Pour point so that it can favourably compete with other lubricants used in sewing machines worldwide.

Keywords: lubricants, thermodynamic properties, volatility, temperature, and oil.

1. Introduction

Liquids are one of the three phases of matter. The molecules of a liquid are loosely packed together and a liquid seeks its level or it takes the shape of its container. Liquids have a definite volume and no form elasticity (no shear modulus), and they are characterized by their strong inter-atomic forces or low compressibility because a slight decrease in the already small inter - atomic separations gives high inter-atomic forces of repulsion [1]. Liquids exist in various forms such as water, oils, solutions, molten solids, and condensed gases to mention but a few. Oils are naturally occurring inorganic or organic substances that are not soluble in water. Most oils containing organic materials are made up of carbon, hydrogen, oxygen, and some elements like phosphorus. Oils are mostly extracted from living animals and plants as well as their dead remains in rocks underground. Liquids like other states of matter have both physical and chemical properties which make them have wide applications in everyday life. For instance, viscosity has made liquids useful as lubricants in moving parts of machines. Furthermore, viscosity is a good parameter for controlling oil quality because it is sensitive to minor variations in temperature, concentration, homogeneity, and the shape and size of molecules. Lubricant's viscosity and blending agents influence the rate at which sensitive components oxidize at the liquid's surface [2]. Other physical properties of liquids that make them useful lubricants include fire point, cloud point, pour point, flash point, and volatility. Thus, the knowledge of the physical properties of liquids is very important, and therefore there is a need to devise means of measuring or determining them.

There are many devices for measuring these physical properties of liquids available in the markets today. The simple and sophisticated forms of these instruments for measuring the physical properties of liquids are available and affordable in developed countries but they are expensive and inadequate in developing countries like Nigeria. This makes it difficult to explore and harness useful information on the potential of locally produced oils in Nigeria. For example, over the years, through personal investigations and interactions with some individuals in the Ganye local government area of Adamawa State, we observed that the majority of tailors make use of Lophira Lanceolata oil (LLO) as a lubricant instead of the conventional Master oil (MO) in their sewing

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p-ISSN 2655-8564, e-ISSN 2685-9432

machines. The tailors ascertained that LLO is a good lubricant, most available, and cheaper than MO. It is against this background that we were motivated to determine the pour, cloud, flash, fire and flash points, and volatility of LLO to ascertain its relative effectiveness as a lubricant in sewing machines.

2. Research Methodology

Lophira, an Ochnaceae family tree also called as Meni oil tree or False shea and known locally as Beung (in Chamba language) and Namijin Kadanya (in Hausa language), grows both in dry and moist evergreen mangroves of tropical Africa [3]. Lophira lanceolata is the predominant species in dry savannah areas, while Lophira Procera is found in West Africa's tropical rain forests. The Lophira tree blooms between the months of December and February. Most parts of the tree (bark, root bark, leaves, and leafy shoots) have been used for traditional medicine. The leaves are additionally employed in traditional rituals and given to livestock [4]. The fruit is bottle-shaped, lobed at the apex, and about 3 cm long, with continual sepals, two of which are expanded and wing-like. Lophira lanceolata seed contains 25 to 30% shell and 70 to 75% kernel, with the remainder yielding approximately 40% to more than 50% yellowish or cream-colored semi-solid fat [4]. In some Nigerian communities as well as other West African countries, the oil is used in preparing food as well as as a hair lotion and lice treatment. Despite their bitter and astringent taste, the seeds are consumed in some regions [4].

Lophira Lanceolata oil has the possibilities to be used as both animal feed and a source of food for humans. Currently, only the fat obtained from the seed is used, which represents about 40 - 50% weight by weight [4]. Whenever the lipid is collected, the cake is considered waste and thus discarded. Regardless of the fact that defatted cake could be an excellent source of protein, it is not utilized as such. There is insufficient knowledge and studies on the chemical makeup of Lophira Lanceolata seeds [5]. Lophira Lanceolata oil's viscosity and density decrease with temperature, suggesting that it is a non-Newtonian liquid, a great lubricant and refrigerant in non-vehicle engines, an attractive corrosion inhibitor, and has bio-fuel prospects [6]. And according to some research findings [7], the chemical classification of Lophira lanceolata oil indicated that it contains polyunsaturated fatty acids (52.6%) and is significant in tocopherols (3.61 mg/100g). The bio - fuel potential was 38.78 (MJ/L), the iodine value was 72.4 (gI2/100g), the saponification value was 223.6 (MgKOH/g), and the free acid was 1.074% [6]. Lophira Lanceolata seeds can be pressed into oil and used as a hair lotion or on the skin to avoid dry skin. This is because of the fact that it is a less volatile and efficient lubricant. [4].

Lubricating oil is the least volatile, most stable portion of petroleum products. Lubricating oils have hydrocarbon structures, with 20 to 70 carbon atoms per molecule, because petroleum products are primarily composed of hydrocarbons. Lubricating oil molecules are divided into three categories paraffinic, naphthenic, and aromatic. Paraffinic molecules mostly have straight chains, are waxy, have a high pour point, good viscosity, and are more temperature stable. Naphthenic molecules are straight chains with a high percentage of five-membered ring structures and a lower percentage of six-membered ring structures. They generally have a low pour point. As a consequence, they are used as cooling oils. They are extremely harmful to humans and are seldom used as lubricating oils. Aromatics are straight chains with six-membered ring benzene structures. In practice, no sharp distinction exists between these various groupings as many lubricating oil molecules are a combination, to varying degrees, of the different types of hydrocarbons [8]. Lubricating oils are fluids such as engine oils, gear, hydraulic oils, turbine oils, etc., used to reduce friction between moving surfaces. They also serve to remove heat from working parts in machinery created by moving surfaces and provide a protective layer on the metal surfaces to avoid corrosion. They as well serve as sealers, filling microscopic ridges and valleys in metal surfaces to enhance the effectiveness of machines and equipment. Furthermore, they act as a cleaning agent, removing dirt and other unwanted materials that might damage bearings or other parts that are operated in close tolerance. Waste is removed from the engine oil or transmission filters. Lubricating oils are typically blended with a range of chemical additives to produce products that last longer and make it possible for machineries to function better in tough operational conditions. Nevertheless, the effectiveness of the lubricants declines over time as the additives undergo chemical changes and

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the oil becomes adulterated with a diverse array of undesirable pollutants as a result of numerous interactions between the components [9].

Oil is used to lubricate moving parts of sewing machines and for the parts to run low or dry of oil will cause the bearings and bushings to prematurely wear, tear, and possibly seize. The effects of running with low or no oil are the most common reason we see that machines are sent in for repair. They are two types of sewing machine oil; they include Synthetic oil (Master oil) and Petroleum oil. The sewing machine is comprised of base oil aromatic (LVI) plus naphthenic (MVI) and paraffinic (HVI)) and additives. These additives give it lube protection, performance, and surface protection. The Flash point, fire point, cloud point, and pour point are all factors that affect the efficiency and dependability of sewing machine oil. The Flash point is the temperature at which the lubricant oil gives off enough vapors to kindle for a fraction of a second when a tiny flame is brought near it, while the Fire point is the lowest temperature at which the lubricant oil vapors burn continuously for a minimum of five seconds whenever a tiny flame is brought near it. The fire points are usually 5 to 40 °C higher than the flash points. The flash and fire points have no direct effect on the oil's lubricating property, but they are important when the oil is exposed to high-temperature service. An excellent lubricant must possess a flash point that is at least greater than the temperature at which it will be used. This protects against the risk of fire throughout operation. A cloud point is the temperature at which a cooling liquid would seem cloudy or hazy, even though the pour point is the temperature at which the lubricant oil ceases to flow or pour. The cloud and pour points of lubricant oil appear to suggest its appropriateness in cold conditions. Lubricant oil used in a machine operating at low temperatures must have a low pour point; otherwise, lubricant oil solidification will cause machine parts to jam.

It is worth noting that temperature is one of the factors that makes oils to have wide applications in science and engineering [11, 12].

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3. Experiments

There were four separate experiments carried out in this work. All the experiments were carried out in the Petroleum Chemistry Department, America University of Nigeria, Yola, Adamawa state, Nigeria.

(a) Cloud Point of MO and LLO.

Samples of the MO and LLO were heated to a temperature slightly above room temperature and were poured into sample bottles with thermometers attached to them. The sample bottles were placed in a water bath of Seta Cloud and pour point Cryostat machine of accuracy ±1.5 °C. The sample bottles were cooled down before being inspected at frequent intervals to check for cloudiness. Thus, every oil sample's cloud point was defined as the temperature when the portion of the thermometer submerged in the oil was no longer visible when seen as horizontally through the oil in the bottle.

(b) **Pour Point of MO and LLO.**

Samples of the MO and LLO at a temperature slightly above room temperature were poured into sample bottles in a water bath of Seta Cloud and pour point Cryostat machine of accuracy ±1.5 °C. Each sample was assessed at regular intervals to see when it stopped flowing. The liquid's pour point was defined by the temperature when the oil surface did not sag for 5 seconds.

(c) **Flash Point and Fire Point of MO and LLO**

Specimens of MO and LLO were poured into separate sample bottles inside an automatic digital PM-93 flash and fire point tester machine of accuracy ±0.1 °C. The flash and fire points were read directly from the tester machine.

(d) Volatility of MO and LLO.

A known mass of 7.4 g for each sample of oil was weighed utilizing a digital balance and placed in separate similar Petri dishes. The two oil samples in the Petri dishes were left to evaporate at the same temperature assuming other weather conditions remained constant. The masses of the oils remaining were recorded utilizing a sensitive digital balance at 20 minutes intervals.

International Journal of Applied Sciences and Smart Technologies
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4. Results and Discussion

Table 1. Cloud, Pour, Flash, and Fire points of MO and LLO.

Liquid property	Master oil (MO)	Lophira lanceolata oil (LLO)
Cloud point	-7.0	23.0
Pour point	-14.0	14.0
Fire point	200.5	294.3
Flash point	198.1	291.5

The experimental values of the cloud, pour, fire and flash points for MO are -7.0^{o}C, -14.0^{o}C, 200.5 ^{o}C, 198.1^{o}C and for LLO are 23.0 ^{o}C, 14.0 ^{o}C, 294.3 ^{o}C, 295.1 ^{o}C respectively (Table 1). These quantities for MO are less than those of LLO. The low pour point of MO shows the possibility of its use even in low-temperature regions of the world as opposed to LLO. For LLO to be applicable in low temperate regions its pour point should be lowered, if possible, below that of MO. This can be achieved by chemically blending LLO with some additives. The flash points and fire points of these oils lie within the maximum temperature range (100-300 ^{o}C) of sewing machines depending on the sewing conditions [10]. Thus, both oils can be safely used as lubricants in sewing machines in temperate regions except LLO needs some modifications such as lowering its pour point to make it applicable even in the Polar Regions of the world.

7.4 g each of MO and LLO kept in the same type of open containers so that they freely evaporated under the same weather conditions and the values of their masses M remaining after time t was recorded in Table 2. The interpretation of the mass-time data can be done in two ways namely linear and exponential relations. In the case of linear relation, mass is plotted against time while in the case of exponential relation, the natural logarithm of mass is plotted against time.

Table 2. Mass remaining at a given time for MO and LLO.

Time (minutes)	Mass (g)	
	LLO	**MO**
0	7.4	7.4
20	7.3	7.1
40	7.2	6.8
60	6.9	6.5
80	6.8	6.3
100	6.7	6.1

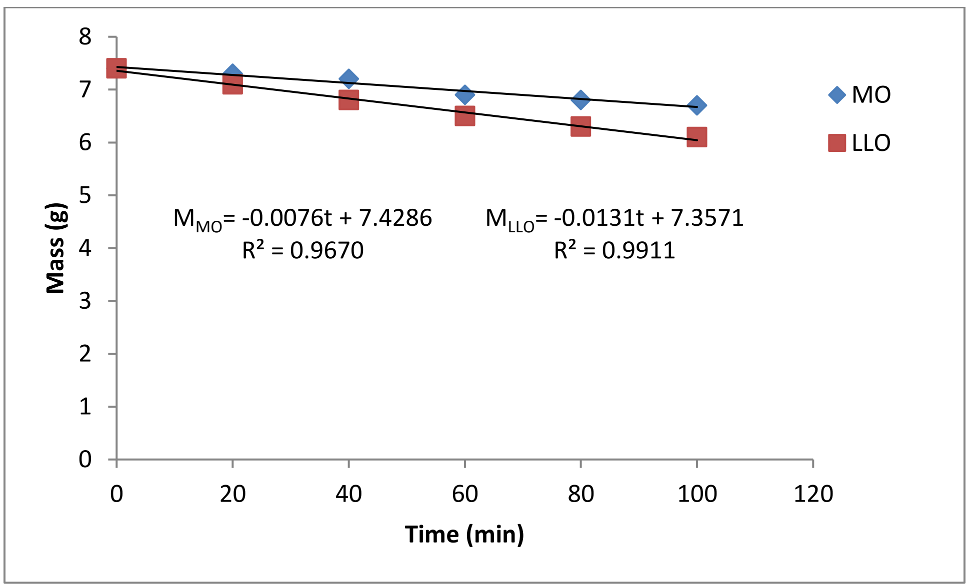

Figure 1. Mass-time lines for MO and LLO

Figure 1 represents the linear relationship and it shows that for both oils the mass remaining decreases with time. The graph of mass, M remaining against time, t yields the following regression lines

$$M_{LLO} = -0.0131t + 7.3571, \quad R^2 = 0.9911 \tag{4.6}$$

$$M_{MO} = -0.0076t + 7.4286, \quad R^2 = 0.9670 \tag{4.7}$$

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where R^2 is the goodness of fit, the subscripts LLO and MO represent lophira lanceolata oil and master oil respectively. The regression lines show that the rate of evaporation of MO is higher than that of LLO. This means MO is more volatile than LLO. Therefore, LLO has the advantage of staying longer on the machine parts than the same amount of MO even though LLO is not treated as compared to the synthetic Master oil. The low volatility of LLO makes it a better lubricant than MO when they are used for a long period.

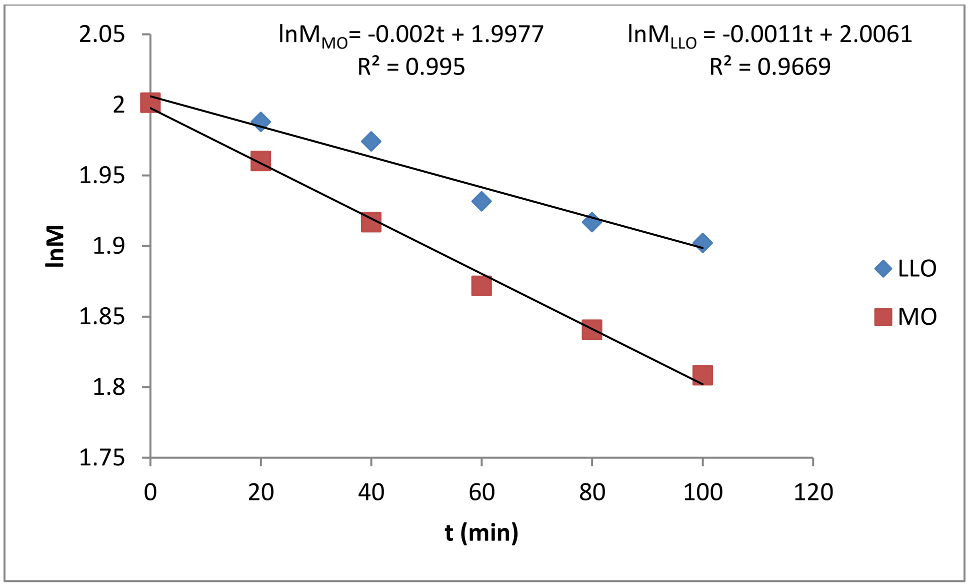

Figure 2. Natural log mass-time lines for MO and LLO

In the case of exponential law, since evaporation obeys the law of exponential decay, the mass M of oil remaining at a time t can be written as $M = M_o e^{-\lambda t}$ where M_o is the initial mass at t=0, λ is the decay constant and e is the number 2.718 to 3 places of decimal. The corresponding half-life or time required for half the amount of oil to evaporate is given by $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$. Fig 3 represents the plot of the natural logarithm of mass of oil remaining at time t against time which yields the following regression equations

$$lnM_{LLO} = -0.0011t + 2.0061, R^2{=}0.9669 \qquad 4.8$$

$$lnM_{MO} = -0.0020t + 1.9977, R^2=0.9950 \quad 4.9$$

The regression equations reveal that the values of the decay constant, λ, and half-life $t_{\frac{1}{2}}$ for MO and LLO are (λ_{MO}=0.0020, λ_{LLO}=0.0011) and ($t_{\frac{1}{2}}(MO) = 346.5\, min,\ t_{\frac{1}{2}}(LLO) = 630.0$ min) respectively. This shows that MO has larger decay constant, almost twice that of LLO, meaning MO evaporates faster than LLO which is in agreement with the linear case. Finally, the exponential relations for LLO and MO are given by $M = M_o e^{-0.0011t}$ and $M = M_o e^{-0.0020t}$ respectively.

5. Conclusion

The study of the flash, fire, cloud, and pour points, and Volatility of master oil (MO) and locally processed lophira lanceolata oil (LLO) were carried out to compare and establish their suitability and effectiveness as lubricants in sewing machines. The results show that LLO has lower volatility than MO, that is, LLO lasts longer in moving parts of a machine than MO. Also, it is observed that the flash point and fire point of the lubricants, MO and LLO, lie within the maximum operating temperature range (<100-300 ^oC) of sewing machines. The pour point (14 ^oC) and cloud point (23 ^oC) of LLO are higher than those of MO at -14 ^oC and -7 ^oC respectively. The high pour point of LLO limits its use as a lubricant in low temperate regions of the world and therefore needs to be chemically blended with some additive agents that can lower its Pour point so that it can favourably compete with other lubricants used in sewing machines worldwide. Finally, the linear relations M_{LLO} = -0.0131t +7.3571, R^2=0.9911 and M_O = - 0.0076t +7.4286, R^2=0.9670 and exponential relations $M = M_o e^{-0.0011t}$ and $M = M_o e^{-0.0020t}$ were obtained respectively where all the symbols have their usual meanings.

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