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Lubricant Base from Palm Oil and Its By-Products



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Field of the invention

- 5 The present invention relates to a biodegradable functional fluid composition for lubricant, hydraulic and like fluid, particularly a functional fluid based on palm oil and its by-products.

Background of the invention

- 10 In the recent years, there has been an increased awareness on the environmental impact of large amounts of lubricants and industrial fluids entering the environment due to leakage or spillage. If the lubricant has little biodegradability, accumulation of these lubricants will result in environmental pollutions.

- 15 The industrial lubricating oil currently in daily use largely based on mineral oils that are highly toxic to the environment. Mineral oils based lubricating oils are not readily biodegradable by microorganisms. Recent studies also indicate that these oils are carcinogenic. Consequently, there is an obvious need for lubricating fluids which are based on renewable natural resources, and at the same time environmentally friendly.

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Vegetable oils are the potential candidates to replace conventional mineral oil based lubricating oils. Natural vegetable oils are non-toxic, exhibit a ready biodegradability, good lubricity and cause fewer health problems such as allergies. Rapeseed oils and sunflower oils are the two most common vegetable oils currently used in the formulation of biodegradable lubricants in Europe.

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- Meanwhile, the use of natural or modified vegetable oil as hydraulic fluid has been disclosed in several patents. Konishi *et al.* (Patent no. US6,300,292) describes the use of rapeseed oil as a suitable base for hydraulic fluid. Honary (Patent no. US5,972,855) used slightly modified soybean oil as a base oil to produce hydraulic fluid. Before this, the soybean oil is partially hydrogenated followed by a winterisation process. Lawate *et al.* (Patent no. US5,538,645) used genetically modified high oleic vegetable oils as base fluid.

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Transesterified oil is another group of base oil used by researchers in the formulation of environmentally acceptable hydraulic fluid. Kodali (Patent no. US6,278,006) transesterified vegetable oil with a short chain fatty acid ester to produce a base suitable for industrial lubricant. Lamsa (Patent no. US5,885,946) described a process of transesterifying vegetable oil with a lower alkanol to produce an alkyl ester and then the alkyl ester is further transesterified with a polyol. Lamsa (Patent no. US5,885,946) provided a method for preparing a base for synthetic lubricant similar to Patent no. US5,885,946 but using the enzymatic route.

- 10 Synthetic ester is yet another group of base fluid used. Hartley *et al.* (Patent no. US6,054,420) described the preparation of a biodegradable lubricant or functional fluid using synthetic ester of polyhydric alcohol. Hartley *et al.* (Patent no. US5,880,075) also described the use of the ester of oxoisodecyl alcohol with iso-stearic acid in combination with polyol ester in the preparation of synthetic biodegradable lubricant. Watanabe *et al.* (Patent no. 15 US5,607,907) disclosed the use of TMP (trimethylolpropane) esters of caprylic or capric acids adjusted with stearic acid as hydraulic fluid.

However, synthetic esters have the problem of higher prices and synthetic esters excellent in biodegradability have the disadvantage of being inferior oxidative stability. On the other hand, the vegetable oil which is excellent in biodegradability and superior in respect of lower prices, but they have poor thermal, oxidative and hydrolytic stability. In general, poor cold temperature properties of natural oil can be improved by increasing the degree of unsaturation in the natural oil. However high degree of unsaturation contributes to poor oxidative stability. For these reasons, the natural oils may only be used in the less severe applications. Rapeseed oil and castor oil, for instance, have been used in lubricants in limited specific applications.

Palm oil, even though possesses good biodegradability and lubricity and better oxidative stability compared to a highly polyunsaturated oil, is not chosen because of its poor cold temperature fluidity.

In order to improve on the properties of vegetable oils, the glycerine molecule of the vegetable oil can be substituted with a hindered alcohol. Usually alcohols without β -hydrogen, such as neopentyl glycol, trimethylol propane and pentaerythritol, are used. The

vegetable oil is first hydrolysed to its fatty acids and glycerol. The hydrolysed fatty acids are then re-esterified with a hindered alcohol. This improves the thermal, oxidative and hydrolytic stability of the oil significantly without affecting much on the biodegradability. This new range of product is generally known as synthetic ester.

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Summary of the invention

Lubricant helps to reduce friction between two contacting metal surfaces thus making the movement easier. In the absence of lubricant, friction caused by the rubbing of the moving parts causes wear and creates heat which welds tiny imperfections on the moving parts together. The parts then tear apart, weld together again, and so on. If allowed to continue will soon cause failure of the engine.

We have now found that vegetable oil and palm oil by-products which are biodegradable are possible to provide satisfactory high performance as a functional fluid.

An object of the present invention is to provide a competitively priced vegetable based functional fluid which possesses good biodegradability, oxidative stability and lubricating properties.

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A further object of the present invention is to prepare a functional fluid having properties which are suitable to be used as hydraulic fluid. This fluid is prepared from a vegetable source, mainly palm oil together with palm oil derivatives. The palm oil is used either in its natural state after undergoing physical refining and fractionation or as derivatives after undergoing chemical modification. Combination of natural oil and derivatives can also be used. The said palm oil derivative is a polyol ester which resulting from chemical reaction between palm oil by-products and hindered polyol.

The combination of natural oil and the said polyol ester is also used and preferred. The resultant properties from this type of combination gave better properties due to the synergetic effect. One of the advantage is the resultant oil have a lower pour point and better oxidative stability than the natural vegetable oil. Moreover it is a good balance between performance and cost.

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functional fluid of the invention can be formulated with one or more additives to enhance the performance of lubricant or hydraulic fluid. Examples of additives for hydraulic fluid include antioxidants, anti-foam additives, anti-wear additives, anti-rust additives, pour point depressants, viscosity-index improver or combinations thereof.

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Detailed description of the invention

This functional fluid could be used as base for lubricant such as the hydraulic fluid to facilitate the movement of construction, industrial or agriculture mechanism such as tractor,
10 soil excavator, agricultural harvesting machine, injection moulding machine, hydraulic elevator, *etc.*

The base fluid use in this invention is palm olein. Palm olein is a liquid fraction obtained when the crude palm oil is fractionated and refined into solid and liquid fractions.
15 Fractionation is performed in order to reduce the content of saturated fatty acids. Typically palm olein has Iodine Value (IV) in the range from about 56 to 72. A vegetable oil has IV higher than 72 could also be used in present invention. Iodine Value is an indication of the degree of unsaturation. Palm olein has been widely used, particularly, as edible oil in many countries, particularly for industrial frying.

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It is well known that the palm olein of lower IV becomes cloudy as the temperature drops. This is due to crystallisation of some of the molecules within the palm olein, particularly the saturated triglycerides.

25 Preferably, the palm olein having IV (iodine value) of 60 or higher, high in tocopherol and tocotrienol content (800 to 1500 ppm), low in free fatty acid (FFA) (< 0.5%), high oleic (46%) and low linoleic and linolenic (16%) content is used in this invention. Thus, the lubricant of the present invention is suitable to be used in tropical regions of countries such as Malaysia, Indonesia, Thailand, Singapore, Brazil or any other country with similar climate.

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The said palm oil derivative is a polyol ester which resulting from chemical reaction between palm oil by-products and hindered polyol. The said palm oil by-product is a mixture of fatty acid having composition of 6 to 12 carbon with caprylic acid (C₈) and capric acid (C₁₀) as its

major compounds. The caprylic acid is in the range of 40 – 60% while capric acid is about 20 – 47% of palm oil by-product.

This by-product could be obtained from the processing of palm oil. For example from the physical refining of palm kernel oil we could get the palm kernel fatty acid distillate (PKFAD) and from the oleochemical industry we could get the pre-cut fraction obtained from the splitting of palm kernel oil and the non-glyceride fraction recovered from the glycerol residue. The pre-cut fraction is especially interesting because it is rich in C₈ and C₁₀ fatty acid.

The said hindered polyol does not contain β -hydrogen are neopentyl glycol, trimethylol propane, pentaerythritol and dipentylerythritol of fatty acids having 6 to 12 carbons. Preferably pentaerythritol is used in the present invention to esterify the fatty acids from palm oil by-product to form pentaerythritol ester.

Preferably synergy additive packages manufactured by *Lubrizol*TM, L7653 and L7671A are added into the formulation of present invention to provide a superior result. L7653 provides a mixture of antiwears that is particularly useful. Antiwear additives absorb on metal, and provide a film that reduces metal-to-metal contact. Whereas, L7671A act as a thickener and pour point depressant to permit flow of the oil formulation below the pour point of the unmodified lubricant.

The hydraulic fluid is prepared by mixing the palm oil, polyol ester and additive packages until the admixture are homogenised. Other vegetable oils such as soybean, rapeseed and sunflower whether in its natural state or after chemical or genetic modification or physical refining to achieve a higher oleic content can also be used in the blend.

The hydraulic fluid in the present invention has viscosity index of at least 190. A lower viscosity index *i.e.* from 150-189 could also be obtained depending on the combination of the blend.

It is to be understood that the present invention may be embodied in other specific forms and is not limited to the sole embodiment described above. However modification and

equivalents of the disclosed concepts such as those which readily occur to one skilled in the art are intended to be included within the scope of the claims which are appended thereto.

Example 1

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Preparation of esters

The polyol ester used in the invention is prepared through esterification process in between palm oil by-product and a hindered polyol. The by-product is a short chain fatty acid mixture of C₆-C₁₂ fatty acids in which caprylic (C₈) and capric (C₁₀) acids as its major composition.

10 Meanwhile, the hindered polyol is pentaerythritol (PE).

Pentaerythritol (1 mole) and fatty acids of C₈₋₁₀ mixtures (4.8 mol) was placed in a multinecked reactor for reaction. The reaction mixture was stirred with an overhead stirrer. The flask was charged with nitrogen gas before the reaction started and the reaction was
15 carried out in the presence of a nitrogen blanket throughout the reaction. The esterification process was carried out at 140°C to 210°C.

The progress of the reaction was monitored by measurements of both the acid content, amounts of water condensate collected in the Dean and Stark apparatus and thin layer
20 chromatography (TLC). When the reaction has completed, the excess fatty acids was distilled over under reduced pressure. Pentaerythritol esters will remain in the flask.

Similarly other polyols such as neopentyl glycol, trimethylol propane and dipentaerythritol could also be used to prepare the polyol esters at different molar ratio.

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Example 2

Preparation of blends

The lubricant is blended by mixing about 20 to 70% by weight of palm olein, relevant
30 amount of polyol ester and additives with a magnetic stirrer for 30 minutes at 50°C until a homogeneous mixture is obtained.

Claims

1. A palm oil-derived polyol ester composition comprising:
 - palm oil by-products; and
 - 5 - alcohol
 wherein said palm oil by-products is esterified by said alcohol.

2. The composition according to Claim 1, wherein said palm oil by-products is any one or combination of:
 - 10 - palm kernel fatty acid distillate (PKFAD) from palm kernel oil;
 - pre-cut fraction obtained from the splitting of palm kernel oil; and
 - non-glyceride fraction recovered from glycerol residue.

3. The composition according to Claim 2, wherein said palm oil by-products having short-
 - 15 chain fatty acids with carbon numbers range from 6 to 12.

4. The composition according to Claim 3, wherein the short-chain fatty acids includes substantially any one or combination of caprylic (C₈) and capric (C₁₀) acids.

- 20 5. The composition according to Claim 1, wherein said alcohol is a hindered polyol.

6. The composition according to Claim 5, wherein said hindered polyol is any one or combination of neopentyl glycol, trimethylol propane, pentaerythritol and dipentaerythritol.
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7. The composition according to Claim 1, wherein the esterification process is carried out at a temperature in the range of 140°C to 210°C.

8. A base fluid composition for a lubricant, hydraulic and like fluid of specific viscosity
 - 30 comprising:
 - vegetable oil, and
 - palm oil-derived polyol ester
 wherein the vegetable oil and palm oil-derived polyol ester admixture are homogenised.

9. The base fluid composition according to Claim 8, wherein the vegetable oil is refined palm oil which treated to reduce the saturated fatty acid (SFA) content.
10. The base fluid composition according to Claim 9, wherein the reduction of SFA content
5 of the palm oil is achieved by fractionation.
11. The base fluid composition according to Claim 10, wherein the palm oil fraction has an iodine value (IV) in the range of from about 56 to 72.
- 10 12. The base fluid composition according to Claim 11, wherein the palm oil fraction has an iodine value exceeding 60.
13. The base fluid composition according to Claim 12, wherein the palm oil fraction has
 - tocopherol and tocotrienol content of the range from about 800 to 1500 ppm;
 - 15 - free fatty acids (FFA) content of less than 0.5%;
 - oleic acid content of at least 46%; and
 - linoleic and linolenic content of about 16%.
14. The base fluid composition according to Claim 8, wherein the palm oil-derived polyol
20 ester includes products from the reaction between a hindered polyol and short-chain fatty acids.
15. The base fluid composition according to Claim 14, wherein the short-chain fatty acids have carbon numbers in the range of 6 to 12.
- 25 16. The base fluid composition according to Claim 15, wherein the short-chain fatty acids includes substantially any one or combination of caprylic (C₈) and capric (C₁₀) acids.
17. The base fluid composition according to Claim 14 to 16, wherein the fatty acids are
30 obtained from any one or combination of the following sources of palm oil by-products:
 - palm kernel fatty acid distillate (PKFAD) from palm kernel oil;
 - pre-cut fraction obtained from the splitting of palm kernel oil; and
 - non-glyceride fraction recovered from glycerol residue.

18. The base fluid composition according to Claim 14, wherein the polyol ester includes esters of any one or combination of neopentyl glycol, trimethylol propane, pentaerythritol and dipentaerythritol.
- 5 19. The base fluid composition according to Claim 18, wherein the polyol ester is pentaerythritol ester.
20. The base fluid composition according to any of the preceding claims wherein the palm oil fraction comprises a portion in the range of from 20 to 70% by weight with the
10 remaining portion being polyol ester.
21. The base fluid composition according to Claim 20, wherein the ratio of palm oil fraction to polyol ester is 1:1.
- 15 22. The base fluid composition according to any one of the preceding claims wherein the viscosity index is at least 150.
23. A hydraulic fluid composition including a base fluid according to any one of Claims 8 to 22 added with suitable additives.
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24. The hydraulic fluid composition according to Claim 23, wherein the additives includes antiwear, thickener and pour point depressant proprietary of *Lubrizol*[™] L7653 and L7671A added at a range of between 1 – 10% and silicone oil added at 0.1 to 1%.
- 25 25. A lubricant composition including a base fluid according to any one of Claims 8 to 24 added with suitable additives.