

AN ELECTRICAL INSULATING FLUID

FIELD OF INVENTION

The present invention relates to an insulating fluid with improved dielectrical breakdown voltage. In more specific, the base oil of the insulating fluid comprises one or more liquid fraction derived from palm oil that the liquid fraction is pre-treated to attain the dielectrical breakdown voltage.

BACKGROUND OF THE INVENTION

Transformer is a device used to transfer electrical energy in much lower voltage to end users such as homes, factories and buildings. Generally, electrical power is generated at very high initial voltages that it needs further processing to lower the voltage at transformer to render the electrical power usable at the end user level. Handling of such high voltages in the transformer requires substantial electrical insulation. Thus, insulation oil plays major roles in electricity transferring, sustainability and efficiency of the transformer.

Conventionally, petroleum-based fluids are used for these types of application for over a century. It is used in oil-filled transformers and some type of high voltage capacitors switches and circuit breakers. The oil performs several functions and has specific requirements. It acts as an insulating medium between energized parts. It cools the equipment by transferring the heat from the windings and core of a transformer to a cooling surface. It also carries information about the condition or health of the transformer. Still, mineral oil or silicon oil are widely used as an insulating medium because it offers good performance and shows excellent compatibility with fabricating material of the transformers. However, few shortcomings of mineral oil-derived insulating fluid have raised significant concern. Particularly, limited biodegradability of these oils may cause damage to soil and water ecosystems persisting for years if the disposal is not handled well or due to accidental spillage. Therefore, there have been attempts to look at new sources for such fluids, including vegetables oil. Such attempts would address both the environmental concerns as well as the

issue of renewability of source. While synthetics fluids are somewhat renewable, they generally still present environmental concerns.

Studies on vegetable based electrically insulating oil has started in early 19 century. However, losing its attention when petroleum provides better offering price. With recent environmental concern, vegetable oils find its way back to the field to be applied as lubricant and insulating medium. These oils offer significant environmental benefits with respect to resource renewability, biodegradability, as well as providing satisfactory performance in a wide array of applications. For example, in 1999, Glenn S. Cannon & Honary has patented the soybean oil based transformer oil (US6207626 B1). The base oil was hydrogenated to produce maximum possible stability of the soybean oil, and winterized to remove crystallized fats and improve the pour point of the base oil without the necessity heating the oil.

In 2001, Charles Patrick Mc Shane and colleagues filed a patent, US6184459 B1, on a new transformer and a method of using a transformer comprising the step of employing in the transformer a dielectric fluid that is essentially a natural food product, the dielectric fluid consisting essentially of a vegetable oil having at least one degree of unsaturation and fire point above 300 °C, wherein the vegetable oil has a viscosity of between 2 and 15 cSt at 100 °C; and less than 110 cSt at 40 °C.

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Thottathil V. Oommen and C. Clair Clairborne filed a patent (US 6645404 B2) in 2003. The patent was related to the high oleic acid triglyceride compositions that comprised of fatty acid components of at least 75% monounsaturated fatty acid, less than 10% diunsaturated fatty acid component; less than 3% triunsaturated fatty acid component; and less than 8% saturated fatty acid component and the composition was further characterized by the properties of a dielectric strength of at least 35kV/100 ml (2.5 mm) gap, dissipation factor of less than 0.05% at 25 °C, acidity of less than 0.03 mgKOH/g, electrical conductivity of less than 1 pS/m at 25 °C, a flash point of at least 250 °C and pour point of at least -15 °C.

Glenn S. Cannon and John A. Kotowski filed a patent (US 2002/0049145 A1) on high flash point and high fire point vegetable oil based electrically insulating fluid. The base oil which comprises of corn oil and soybean oil is hydrogenated to produce maximum possible stability or alternative to get higher oleic acid oil. The oil can be winterized to remove crystallized fats and improve the pour point of the base oil. The base oil is then combined with an additives package containing materials specifically designed for improved cooling properties and improve dielectrical stability. The invention also provides methods for making the fluid and fluid-filled electrical components. Further, United States patent publication no. 2010065792 discloses a biodegradable dielectric fluid comprising an oil or mixture of oils having oleic acid content greater than 75% with natural tocopherol content greater than 200ppm and a metal deactivator.

SUMMARY OF THE INVENTION

The present invention aims to provide an electrical insulating fluid derived from a sustainable source. In more specific, the insulating fluid can be composed of an oil fraction or mixture of oil fractions extracted from oil palm. The oil fractions can be crude palm oil or other treated fraction obtained from the crude palm oil.

Another object of the disclosed invention is to provide plant based insulating oil with improved dielectrical breakdown voltage. The disclosed insulating oil shows better resistance towards high voltage-induced degradation as the threshold of dielectrical breakdown voltage has greatly increased.

Still another object of the present invention is to offer an electrical insulating fluid inherently possessing anti-oxidant properties owing to tocotrienols and tocopherols naturally produced in the palm oil.

Further object of the present invention is to disclose an insulating fluid composition including additives that increase the functional properties of the fluid. The present composition

preferably has efficient kinematic viscosity, dielectrical strength, high flash point and substantially a plant-based product poses no environmental or health safety hazard.

At least one of the preceding objects is met, in whole or in part, by the present invention, in which one of the embodiment of the present invention involves an insulating fluid for electric appliance comprising a base oil of one or more palm oil derived liquid fraction with reduced moisture content; and an additive, wherein the liquid fraction is heated between 50°C to 150°C under a negative pressure to reduce the moisture content. More preferably, the liquid fraction has reduced moisture content less than 0.1%.

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Further aspect of the present invention that the additive is an anti-oxidant, an anti-microbial, a metal deactivating agents or any combinations thereof.

In another aspect, the liquid fraction is any one or combination of crude palm oil, RBD palm olein, red palm oil, superolein, isopropyl myristic, isopropyl palmitic, methyl laurate, methyl myristate, methyl stearate, methyl oleate, butyl oleate, glycerol trioleate, caprylic acid and oleic acid. Yet, more preferably, base oil has a mixture of the liquid fraction containing 10-90% by weight of RBD palm olein and 10-90% by weight of crude palm oil.

20 DETAILED DESCRIPTION OF THE INVENTION

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.

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The preset invention includes an insulating fluid for electric appliance comprising a base oil derived from one or mixture of palm oil-derived liquid fractions with reduced moisture content; and an additive; wherein the base oil is heated between 50°C to 150°C under a negative pressure to reduce the moisture content. In more specific, the base oil can be any one or combination of, but not limited to, crude palm oil, refined-bleached-deodorized (RBD)

palm olein, red palm oil, superolein, isopropyl myristic, isopropyl palmitic, methyl laurate, methyl myristate, methyl stearate, methyl oleate, butyl oleate, glycerol trioleate, caprylic acid and oleic acid. More preferably, the liquid fraction is 10-90% by weight of RBD palm olein and 10-90% by weight of crude palm oil, most preferably the liquid fraction is 50-90% by 5 weight of RBD palm olein and 10-50% by weight of crude palm oil. In the present invention, RBD palm olein (RBD POo) is more preferably employed as one of the major fraction composing the base oil. The RBD palm olein is a liquid fraction of palm oil contains higher unsaturation compared to RBD palm oil. At ambient temperature of 27-30°C, it is clear of crystal. The iodine value of RBD POo is about 56 gI₂/100g. In RBD palm olein, oleic acid is 10 the major fatty acid forming about 42%, palmitic acid about 39%, linoleic acid about 11.6% and linolenic about 0.3%. Low content of linoleic acid and linolenic acid render RBD palm olein fraction oxidatively stable.

According to another embodiment, the liquid fraction can be 10-90% by weight of super 15 olein and 10-90% by weight of crude palm oil. Superolein is higher in liquid fraction compared to RBD POo and obtained from the fractionation of RBD POo. The iodine value of superolein is at least 64 gI₂/100g. The base oil derives from this oil blend shows lower cloud point or solidified temperature and can be used in country with cold climate. Still, another preferred embodiment, the base oil has oleic acids and palmitic acids content not less than 20 60% by weight. RBD palm olein, red palm oil and superolein used in the present invention preferably have kinematic viscosity of at least 30 mm²/s at 40 °C and 5 mm²/s at 100 °C. Further embodiment of the liquid fraction may include a mixture of 50-90% by weight of RBD palm olein and 10-50% by weight of red palm oil, or a mixture of 50-90% by weight of RBD palm olein and 10-50% by weight of superolein. Nonetheless, the liquid fraction may be 25 constituted of single type of palm oil fraction such as crude palm oil, red palm oil, RBD palm olein or superolein only instead of mixture of different fractions.

To achieve better performance in insulating oil, treatment is conducted to the base oil to remove or reduce the moisture content. The treated base oil shows improved dielectrical 30 strength. It is important to be noted that the liquid fraction of the present invention can be

subjected to the setting forth process to reduce the moisture content prior to homogenously mixing to form the base oil. Though, it is more preferred in the present invention that the selected one or more liquid fractions are blended to form homogeneous mixture only then subjected to the process for moisture content reduction. In one embodiment, the treatment is

5 carried out by heating between 50-110 °C, under a negative pressure, preferably 10-20 mbar vacuum, for 30– 90 minutes. Under the influence of negative pressure, the water content contained in the base oil can be evaporated at a much lower temperature. High heating temperature has to be avoided as it leads to oxidation and degradation of the base oil. It was found by the inventors of the present invention that the breakdown dielectrical voltage value

10 of the base oil has significantly improved compared to untreated base oil. The treatment increase breakdown dielectrical voltage value of different treated fractions or blends to at least 60kV, while other properties remain unchanged after the treatment. Further, the treated base oil together with the additives are stored in a substantial hermetically sealed contained to prevent moisture before it is used. Preferably, additives are added and mixed with the base oil

15 after the treatment to keep the additive from being affected by the heat. Particularly, phenolic types of inhibitor to be added into the base oil may be vaporized reducing the actual amount contained in the base oil. The affected base oil may suffer from shortened lifetime. Preferably, the liquid fractions or the base oil has reduced moisture content less than 0.05%.

20 One shall appreciate the fact that different additives can be added and mixed with the base oil to either enhance the insulating efficiency or prolong the service life of the insulating liquid. Preferably, additives can be used in the present invention are anti-oxidant, anti-microbial and/or metal deactivating agents. In some preferred embodiments the antioxidant used is, but not limited to, tocotrienol, carotenoid and/or tertiary butylhydroquinone (TBHQ). It is

25 preferred that the antioxidants are in a concentration of 100-1000 ppm in the base oil. The tocotrienol and carotenoid employed in these embodiments may inherently derive from crude palm oil fraction used in the base oil, while TBHQ is phenolic antioxidant and a highly effective preservative for unsaturated vegetable oils and many edible animal fats. Nevertheless, commercially available tocotrienol and TBHQ can be employed as well to have the

30 antioxidants attained the preferred concentration in the base oil. The antioxidant retards

potential oxidative reaction in the base oil stored in the transformer and protects the base oil from oxidative degradation. Thus the electric appliance can perform for an extended period.

Likewise, antimicrobial agent in the base oil aims to inhibit growth of microbes which can lead to degradation of the insulating liquid. Preferably, the antimicrobial agents are citric acid and/or butylated hydroxyanisole (BHA). The preferred amount of the antimicrobial is in the range of about 10-1000 ppm.

Metal deactivators, or metal deactivating agents (MDA) are additives used in the present invention to stabilize the liquid fraction in the base oil by deactivating metal ions generated by oxidative processes with the metallic parts of the systems. Metal deactivators inhibit the catalytic effects of such ions, especially copper in the electric appliance, retarding the formation of gummy residues. In electric appliance like high voltage transformer, metal ions like copper as low concentrations as 0.1 ppm can cause detrimental effects to the service life and performance of the transformer. In the preferred embodiments, the metal deactivator can be IRGAMET 30 or SARKOSYL®O which are commercially available. IRGAMET 30 is a triazole derivative, N,N-bis (2-Ethylhexyl)-1H-1,2,4-triazole-1-methanamine and SARKOSYL®O is a N-acyl sarcosine. It is clear and brownish yellow liquid. The preferred amount of metal deactivators in the base oil is around 10-150ppm.

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The following example is intended to further illustrate the invention, without any intent for the invention to be limited to the specific embodiments described therein.

Example 1

25 Palm oil typically comprises a mixture of glycerides. A glyceride is a reaction product from a molecule of glycerol and one to three molecules of fatty acids. The fatty acids could be of the same type or they could be different. The property of a triglyceride will depend on the different fatty acids that combined to form the triglyceride. The fatty acids themselves are different depending on their chain length and degree of saturation. The short chain fatty acids have lower melting point. Glycerides composition in palm oil normally contains triglycerides

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(93-95%), diglycerides (5-7%), monoglycerides (0.2-1.0%) and minor component (~1%). Minor components of palm oil and palm kernel oil are fat soluble components such as carotenoids, tocopherols, sterols, phosphatides, sterols, squalene, coenzyme Q, terpenoids and aliphatic alcohols. Although present at low concentration of less than 1%, they are important as imparting oxidative stability to the oil. Crude palm oil (CPO) contains 500 – 700 ppm of carotenoids and 700- 1000 ppm of tocopherols. Refined oil does not contain these carotenoids and tocopherols because they are removed during refining.

Several different fatty acids molecules on a triglyceride molecule exists including the following, may be present are caproic, caprylic, capric, lauric, myristic, palmitic, stearic, arachidic, palmitoleic, oleic, linoleic and linolenic. The presence of oleic acid which contains one unsaturation or a double bond imparts the stability of the oil whereas, the longer chain fatty acids have higher melting points. The melting point is also dependent on degree of unsaturation. Unsaturated acids will have a lower melting point compared to saturated fatty acids of similar chain length. The predominant fatty acids in palm oil are C16:0 (saturated) palmitic acid and C18:1 (unsaturated) oleic acid. Typical fatty acid compositions of palm oil are as shown in Table 1.

TABLE 1: FATTY ACID COMPOSITIONS OF PALM OIL AND PALM OLEIN

Fatty Acid	Carbon chain	Palm Oil (%)	Palm Olein (%)	Super Olein (%)
Lauric	C12	0.1-0.2	0.2-0.4	0.2-0.4
Myristic	C14	1.0-1.4	0.9-1.2	0.5-1.5
Palmitic	C16	40.9-47.5	38.2-42.9	34.5-37.4
Stearic	C18	3.8-4.8	3.7-4.8	3.5-4.0
Oleic	C18:1(9)	36.4-41.2	39.8-43.9	43.0-47.0
Linoleic	C18:2(9, 12)	9.2-11.6	10.4-12.7	12.5-14.5
Linolenic	C18:3(9, 12, 15)	0.0-0.5	0.1-0.6	0.0-0.5

According to the invention, the properties of palm oil and its derivatives for insulation were identified. Some oils complied with an international standard specification (ASTM D6871-Natural ester based insulating fluid) and they are applicable for this application. Screening of

palm oil and its derivatives on this application was carried out. The values of the tests are shown in Table 2.

TABLE 2: SCREENING TEST OF SOME PALM OIL DERIVATIVES

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	Dielectrical Breakdown Voltage (kV)	Moisture Content (%)	Kinematic Viscosity mm ² /s	
			@ 40 °C	@ 100 °C
RBD Palm Kernel Oil	29	0.0500	30.25	6.46
RBD POo	40.87	0.0160	40.58	8.48
CPO	78.1	0.1751	-	82.65
Superolein	39.8	0.0960	39.31	8.33
Isopropyl Myristic IPM	89.5	0.0487	3.93	1.6
Isopropyl Palmitic, IPP	77.6	0.0334	5.12	1.92
Methyl Ester (C ₁₂)	42	0.0101	2.48	1.17
Methyl Ester (C ₁₄)	15	0.0920	3.29	1.42
Methyl Ester (C ₁₆)	21	0.0310	4.38	1.69
Oleic Acid	88.8	0.0570	19.23	4.8
Caprylic Acid	64.1	0.0789	4.03	1.56
Glycerol Trioleate	60	0.1470	39.74	8.55

Example 2

Like others vegetable oil, palm oil is also more hygroscopic than petroleum oil. In this application, moisture becomes the most severe problem not only to transformer but in any electrical device. As its main function is to insulate the core winding from contacting each other, the moisture should be as low as possible. The excess of moisture content may lower the dielectrical strength. Some of the effort was focused on the treatment of oil by removing the excess of moisture to increase the dielectrical strength. The base oil was significantly having higher dielectrical strength after treatment. The dielectrical breakdown voltage (BDV) value of oil was increased to 63.6 kV after heated up to 80-110 °C for 45-90 minutes hour with the aid of 10-20 mbar vacuum. The study on the treatment was carried out for CPO, RBD POo, palm based derivatived oils (PBDOS) and blendings without additives. Table 3 shows the BDV value of treated and untreated of CPO, RBDPOo and their blending without additives.

TABLE 3: Formulation of palm based transformer oil

	BDV, kV	
	Untreated	Treated
CPO (Moisture = 0.0507%)	25.6	75
RBD POo (Moisture = 0.0526%)	31.36	66.6
75% RBD POo + 25% CPO	21.7	78
50% RBD POo + 50% CPO	22.6	72.7
25% RBD POo + 75% CPO	21.1	73

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Some antioxidants were identified to be incorporated into the formulation in order to enhance the stability of the oil. Tocotrienol which is also obtained from palm oil was chosen in this study. Tocotrienol was identified having good BDV value of 69.9kV. There are several fundamental properties of transformer oils for example oxidation stability, dielectrical breakdown voltage, pour point, sludge and acid formation, kinematic viscosity and moisture content. Their properties must meet the international standard requirement that allow them to function satisfactorily.

Changes therein and other uses will occur to those skilled in the art which are encompassed within the scope of the invention as defined by the scope of the claims.

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Claims

1. An insulating fluid for electric appliance comprising
a base oil derived from one or mixture of palm oil-derived liquid fractions including
5 any one or combination of crude palm oil, RBD palm olein, red palm oil, superolein,
isopropyl myristic, isopropyl palmitic, methyl laurate, methyl myristate, methyl
stearate, methyl oleate, butyl oleate, glycerol trioleate, caprylic acid and oleic acid
with reduced moisture content; and
an additive, wherein the base oil is heated between 50⁰C to 150⁰C under a negative
10 pressure to reduce the moisture content.
2. An insulating fluid of claim 1, wherein the liquid fraction has reduced moisture
content less than 0.05%.
- 15 3. An insulating fluid of claim 1, wherein the liquid fraction has oleic acids and palmitic
acids content not less than 60% by weight
4. An insulating fluid of claim 1, wherein the additive is an anti-oxidant.
- 20 5. An insulating fluid of claim 1, wherein the additive is an anti-microbial.
6. An insulating fluid of claim 1, wherein the additive is a metal deactivating agents.
7. An insulating fluid of claim 1, wherein the liquid fraction is 10-90% by weight of
25 RBD palm olein and 10-90% by weight of crude palm oil.
8. An insulating fluid of claim 1, wherein liquid fraction is 50-90% by weight of RBD
palm olein and 10-50% by weight of red palm oil.

9. An insulating fluid of claim 1, wherein liquid fraction is 50-90% by weight of RBD palm olein and 10-50% by weight of superolein.