

Dielectric fluid comprising esters of fatty acids

Field of the invention

5 The present invention relates to the use of a composition based on fatty acid (preferably methyl) esters, preferably derived from castor oil, as a dielectric fluid in various electrical devices such as transformers and capacitors.

Technical background

10 Many electrical devices such as capacitors and transformers contain a dielectric (or insulating) fluid. The function of this fluid is to isolate the high-voltage components from the other parts of the device and to convey the heat to the environment in order to cool the unit.

 It is known to use mineral oils as dielectric fluids in these applications.
15 Moreover, in an effort to reduce the environmental impact of dielectric fluids, compositions based on vegetable oils have also been proposed. They are generally formulated with antioxidant type additives allowing to improve the oxidation stability of the fluid.

 Thus, document US 2002/027219 describes an oleic acid-rich oil composition
20 used as an electrical insulation fluid, suitable for electrical devices in combination with several antioxidant type additives, pour point depressant additives and copper deactivators.

 Document US 2008/283803 discloses a dielectric fluid composition comprising a pretreated vegetable oil (i.e. refined, bleached and deodorized), one or more
25 antioxidant compounds, and one or more pour point depressant agents.

 Dielectric fluids containing ester compounds are also known.

 Thus, document WO 2012/001043 proposes an additive derived, for example, from oleic acid, modified by reaction with an isopropyl chloroformate type compound, for dielectric oils. Advantages in terms of viscosity reduction, oxidation stability, increase in
30 permittivity, and pour point reduction are discussed.

Document US 2014/252281 relates to the use of a functionalized methyl-12-hydroxymethyl-stearate type synthetic esters obtained by hydroformylation and hydrogenation of oleic acid.

Document US 2015/0228373 discloses the use of synthetic esters with one or
5 more additives (antioxidants, metal deactivators and pour point depressant agents) as dielectric fluids in electrical devices. The synthetic esters are prepared by reacting pentaerythritol with certain selected carboxylic acids.

Furthermore, document EP 1623785 discloses the use of fatty acid methyl and ethyl esters, mainly based on oleic acid, as a dielectric fluid in a completely different
10 application, namely electro-erosion machining and more particularly electric discharge machines (EDM). In this application, the machining tool and the machined part are immersed in a dielectric fluid.

There is a need to provide dielectric fluid compositions for electrical devices such as capacitors and transformers having low environmental impact and having high
15 electrical insulation performance, particularly in terms of breakdown voltage.

Summary of the invention

The invention primarily relates to the use of a composition comprising a mixture of vegetable oil fatty acid esters as a dielectric fluid in an electrical device.

20 According to one embodiment, the electrical device is chosen from transformers, capacitors and electric cables.

According to one embodiment, the vegetable oil is castor oil.

According to one embodiment, the mixture of vegetable oil fatty acid esters is a mixture of vegetable oil fatty acid methyl esters.

25 According to one embodiment, the mixture of vegetable oil fatty acid esters comprises:

- methyl stearate, preferably in a mass content of 1 to 20%, more preferably less than 15%; and/or
- methyl oleate, preferably in a mass content of 1 to 90%, more preferably of
30 25 to 35%; and/or

- methyl linoleate, preferably in a mass content of 1 to 80%, more preferably of 35 to 45%; and/or
- methyl palmitate, preferably in a mass content of 1 to 50%, preferably less than 10%; and/or
- 5 - methyl ricinoleate, preferably in a mass content of 0 to 4%, more preferably of 2 to 3%; and/or
- 10-undecylenic acid, preferably in a mass content of 0 to 1%.

According to one embodiment, the composition essentially consists, or even consists, of the mixture of vegetable oil fatty acid esters.

10 According to one embodiment, the composition comprises a pour point depressant additive, preferably in a mass proportion of 0.1 to 5%, preferably of 1 to 2%.

According to one embodiment, the composition essentially consists, or even consists, of the mixture of vegetable oil fatty acid esters and the pour point depressant additive.

15 According to one embodiment, the pour point depressant additive is an acrylic polymer dissolved in an oil.

The invention also relates to an electrical device comprising an enclosure containing a composition comprising a mixture of vegetable oil fatty acid esters as a dielectric fluid.

20 According to one embodiment, the electrical device is chosen from transformers, capacitors and electric cables.

According to one embodiment, the composition in the electrical device is as described above.

25 The present invention makes it possible to overcome the disadvantages of the prior art. More particularly, it provides dielectric fluid compositions for electrical devices such as capacitors and transformers, having low environmental impact and having high electrical insulation performance.

This is accomplished by providing compositions based on fatty acid methyl esters obtained by transesterification of vegetable oil.

30 In some advantageous embodiments of the invention:

- the compositions according to the invention have a high breakdown voltage that is greater than the minimum specification required by the IEC 62770 standard;
- the compositions according to the invention may be produced easily and at a moderate cost;
- the compositions according to the invention have a low viscosity;
- the compositions according to the invention exhibit good biodegradability;
- the compositions according to the invention may contain little or no additives (expensive, toxic and non-biodegradable) such as the antioxidants or the metal deactivators commonly used in the formulations of the prior art.

Description of embodiments of the invention

The invention is now described in more detail and without limitation in the description which follows.

The invention relates to the use of a composition comprising a mixture of vegetable oil fatty acid esters, preferably vegetable oil fatty acid methyl esters, as a dielectric fluid in an electrical device.

This mixture of vegetable oil fatty acid esters is a mixture which may be obtained by transesterification of a vegetable oil with an alcohol, preferably a linear alcohol, more preferably a C1 to C5 linear alcohol, preferably C1 to C2.

Possible alcohols are methanol, ethanol, propanol, butan-1-ol, butan-2-ol, 2-methylpropan-1-ol, 2-methylpropan-2-ol, pentan-1-ol, pentan-2-ol, pentan-3-ol, 2-methylbutan-1-ol, 2-methylbutan-2-ol, 3-methylbutan-2-ol, 3-methylbutan-1-ol, and 2,2-dimethylpropan-1-ol.

A mixture of the above alcohols may also be used.

Preferably the alcohol comprises methanol. More preferably, only methanol is used.

The transesterification rate of the mixture is not necessarily 100%, which means that the ester mixture in question may comprise a certain proportion of unesterified fatty acids.

The vegetable oil may be pretreated before the transesterification step. However, it is preferably not pretreated before this step. It may advantageously undergo a post-treatment step after the transesterification, such as purification by distillation.

5 It should be noted that the fatty acid composition varies considerably from one vegetable oil to another.

The vegetable oil may notably be a castor oil, a rapeseed oil, a soybean oil, a sunflower oil, an olive oil, a cottonseed oil, a palm oil, a coconut oil, a corn oil, a seaweed oil, an Abyssinian oil, a safflower oil, a lesquerella oil or a mixture thereof.

More particularly preferably, it may be a castor oil.

10 The fatty acid ester mixture concerned by the present invention derives from fatty acids which are saturated and unsaturated, and preferably have chain lengths comprised between C8 and C26, preferably between C10 and C22; wherein these fatty acids preferentially include palmitic (C16), stearic (C18) oleic (C18:1) and linoleic (C18:2) acids.

15 According to one embodiment, the mixture of vegetable oil fatty acid esters comprises methyl oleate (C18:1), preferably in a mass content of 1 to 90%, preferably of 20 to 40%, more preferably of 25 to 35%.

20 According to one embodiment, the mixture of vegetable oil fatty acid esters comprises methyl linoleate (C18:2), preferably in a mass content of 1 to 80%, preferably of 30 to 50%, more preferably of 35 to 45%.

According to one embodiment, the mixture of vegetable oil fatty acid esters comprises methyl stearate (C18:0), preferably in a mass content of 1 to 20%, preferably of 5 to 20%, more preferably less than 6 to 15%, and more preferably of 8 to 12%.

25 According to one embodiment, the mixture of vegetable oil fatty acid esters comprises methyl palmitate (C16:0), preferably in a mass content of 1 to 50%, preferably in a mass content of less than 10%, and more preferably less than 8.5%.

According to one embodiment, the mixture of vegetable oil fatty acid esters comprises methyl ricinoleate (C18:1(OH)), preferably in a mass content of 0% to 4%, more preferably of 1.5 to 4%, and in particular of 2 to 3%.

According to one embodiment, the mixture of vegetable oil fatty acid esters comprises 10-undecylenic acid (C11:1), preferably in a mass content of 0 to 1.5%, more preferably of 0.4 to 1.2%, and, in particular of 0.6 to 1%.

Such a product is notably marketed by Arkema under the designation Oleris®

5 Esterol A.

According to one embodiment, the mixture of vegetable oil fatty acid esters simultaneously comprises methyl stearate, methyl oleate, methyl linoleate, methyl palmitate, and may contain methyl ricinoleate and 10-undecylenic acid, preferably in the mass contents indicated above.

10 Alternatively, if another alcohol than methanol is used for the transesterification, the mixture of vegetable oil fatty acid esters may comprise the various esters mentioned above, preferably in the proportions mentioned above, by replacing the term "methyl" by another alkyl group (e.g. "ethyl" if ethanol is used, etc.).

According to one embodiment, the composition of the invention is devoid of
15 pour point depressant additive.

According to an alternative embodiment, the composition of the invention comprises a pour point depressant additive.

The pour point depressant additive is preferably selected so that it enables the pour point of the composition according to the invention to be lowered below 0°C
20 (preferably below -1°C, or -2°C, or -3°C, or -4°C, or -5°C, or -6°C, or -7°C, or -8°C, or -9°C according to the ASTM D97 standard).

Suitable pour point depressants include acrylic polymers (which includes acrylic copolymers), preferably a polyalkyl methacrylate. A particularly suitable additive is the product marketed by Evonik under the reference VISCOPLEX® 1-211.

25 The additive may be present in the composition in a mass proportion of 0.1 to 5%, and preferably of 1 to 2%.

A mixture of castor oil fatty acid (methyl) esters with such a pour point depressant additive is notably marketed by Arkema under the designation Oleris® Esterol F.

According to one embodiment, the composition of the invention may comprise other dielectric compounds or various additives, such as antioxidants or metal deactivators.

5 However, it is preferred that the composition of the invention is essentially devoid, or even completely devoid, of such compounds and additives.

In particular, according to one embodiment, the composition of the invention is essentially devoid, or totally devoid, of antioxidant.

According to one embodiment, the composition of the invention is essentially devoid, or totally devoid, of metal deactivator.

10 According to one embodiment, the composition of the invention consists essentially of the mixture of vegetable oil fatty acid esters and, where appropriate, the pour point depressant additive described above. According to another embodiment, the composition consists of the mixture of vegetable oil fatty acid esters and, where appropriate, the pour point depressant additive.

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Examples

The following examples illustrate the invention without limiting it.

Various properties that are important for use as dielectric fluid have been determined on the products marketed by Arkema under the references Oleris® Esterol A and F, which
20 are compositions in accordance with the invention.

The results are summarized in the table below. The required thresholds are based on the IEC 62770 standard.

Property	Test method	Threshold	Oleris® Esterol A	Oleris® Esterol F
Viscosity at 40 °C	ISO 3104	Max. 18 mm ² s ⁻¹	< 5 mm ² s ⁻¹	< 10 mm ² s ⁻¹
Breakdown voltage	CEI 60156	Min. 35 kV	78 kV	76 kV
Fire point	ISO 2592 (open cup)	Min. 175°C	198°C	192°C
Flash point	ISO 3679 (closed cup)	Min. 135°C	173°C	167°C
Biodegra- dation	US EPA OCDE 301 B	Easily biodegradable	Easily biodegradable 75% after 28 days	Easily biodegradable 75% after 28 days

In addition to having breakdown voltage values that are significantly higher than the minimum specification of 35 kV, both products comply with the physical (viscosity at 40°C) and safety (fire point $\geq$ 175°C, flash point $\geq$ 135°C) criteria, and are easily biodegradable.

The breakdown voltages were then compared with those of other plant-based products containing triglycerides and additives (antioxidants and/or metal deactivators).

The composition of comparative example 1 contains more than 98.5% of soybean oil, less than 1% of antioxidant, less than 1 % of pour point depressant, and less than 1% of dye.

The composition of comparative example 2 contains 98.4% of sunflower oil with a high oleic acid content and 1.6% of antioxidants and of metal deactivator.

Product	Oleris® Esterol A	Oleris® Esterol F	Comparative example 1	Comparative example 2
Breakdown voltage (kV)	78	76	47	45

The Oleris® Esterol A and F products, in addition to their low viscosity, their biodegradability, their plant origin, and the absence of antioxidant and metal deactivator in their composition, therefore have intrinsic breakdown tensions far higher than dielectric fluids based on vegetable oil and formulated with additives.

CLAIMS

1. Use of a composition comprising a mixture of castor oil fatty acid methyl esters as a dielectric fluid in an electrical device, wherein the mixture of castor oil fatty acid methyl esters comprises methyl stearate in a mass content of 1 to 20%, methyl oleate in a mass content of 1 to 90%, methyl linoleate in a mass content of 1 to 80%, methyl palmitate in a mass content of 1 to 50%, methyl ricinoleate in a mass content of 2 to 3% and 10-undecylenic acid in a mass content of 0 to 1%.

2. Use according to claim 1, wherein the electrical device is chosen from transformers, capacitors and electric cables.

3. Use according to one of the claims 1 to 2, wherein the mixture of castor oil fatty acid methyl esters comprises:

- methyl stearate, in a mass content of less than 15%; and/or
- methyl oleate, in a mass content of 25 to 35%; and/or
- methyl linoleate, in a mass content of 35 to 45%; and/or
- methyl palmitate, in a mass content of less than 10%; and/or
- methyl ricinoleate, in a mass content of 2 to 3%; and/or
- 10-undecylenic acid, in a mass content of 0 to 1%.

4. Use according to one of the claims 1 to 3, wherein the composition essentially consists, or even consists, of the mixture of castor oil fatty acid methyl esters.

5. Use according to one of the claims 1 to 3, wherein the composition comprises a pour point depressant additive, preferably in a mass proportion of 0.1 to 5%, preferably of 1 to 2%.

6. Use according to claim 5, wherein the composition essentially consists, or even consists, of the mixture of castor oil fatty acid methyl esters and the pour point depressant additive.

7. Use according to one of the claims 5 to 6, wherein the pour point depressant additive is an acrylic polymer dissolved in an oil.

5 8. Electrical device comprising an enclosure containing a composition comprising
a mixture of castor oil fatty acid methyl esters as a dielectric fluid, wherein the mixture of
castor oil fatty acid methyl esters comprises methyl stearate in a mass content of 1 to
20%, methyl oleate in a mass content of 1 to 90%, methyl linoleate in a mass content of
1 to 80%, methyl palmitate in a mass content of 1 to 50%, methyl ricinoleate in a mass
10 content of 2 to 3% and 10-undecylenic acid in a mass content of 0 to 1%.

9. Electrical device according to claim 8, which is chosen from transformers,
capacitors and electric cables.

15 10. Electrical device according to claim 8 or 9, wherein the composition is as
described in claims 3 to 7.