Title of the Invention: **Improvements in and relating to dielectric fluids**

Abstract Title: **Dielectric fluid composition**

The invention relates to dielectric fluids and esters, particularly, to ester compositions suitable for use in dielectric fluid compositions, as well as to dielectric fluid compositions, methods of manufacturing ester compositions and dielectric fluid compositions and to electrical apparatus (e.g. transformers) comprising the ester and dielectric fluid. The esters are derived from a reaction of (a) one or more alcohols selected from C2 and C3 polyols (e.g. glycerol or ethylene glycol), and (b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid (e.g. 2-ethyl-hexanoic acid). There are also one or more additives, e.g. antioxidant, metal deactivator or pour point depressant.
Improvements in and relating to dielectric fluids

FIELD OF INVENTION

The present invention relates to dielectric fluids and esters, particularly, though not exclusively, to ester compositions suitable for use in dielectric fluid compositions as well as to dielectric fluid compositions, methods of manufacturing ester compositions and dielectric fluid compositions and to electrical apparatus.

BACKGROUND TO INVENTION

The use of dielectric fluids in electrical apparatus such as transformers is well known. Dielectric fluids known for such use include mineral oil based fluids, natural ester based fluids and synthetic ester based fluids. Known synthetic esters include those produced from the reaction of an alcohol with carboxylic acids. Dielectric fluids based on such synthetic esters have a number of advantages over mineral oil based fluids but there remains a need for synthetic esters having improved properties.

Accordingly, the present invention aims to address at least one problem associated with known dielectric fluids whether discussed herein or otherwise.

SUMMARY OF INVENTION

According to a first aspect of the present invention there is provided an ester composition, wherein the ester composition comprises one or more esters derived from a reaction of:
(a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and
(b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.

Suitably, alcohol (a) is selected from the group consisting of:
(i) glycerol; and
(ii) ethylene glycol.

Suitably, the ester composition comprises a single ester, wherein the ester is derived from a reaction of glycerol with 2-ethylhexanoic acid.

Suitably, the ester composition comprises one or more esters derived from a reaction of an alcohol and two or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid. Suitably, the ester composition comprises one or more esters of an alcohol and one or more saturated fatty acids.

Suitably, the one or more C4 to C14 carboxylic acids comprise a combination of 2-ethylhexanoic acid and a branched C9 carboxylic acid, such as, for example, 3,5,5-trimethylhexanoic acid; or a combination of 2-ethylhexanoic acid, a linear C8 carboxylic acid and a linear C10 carboxylic acid.

Suitably, the amount of the branched C9 carboxylic acid, or of the combined linear C8 and C10 carboxylic acids, constitutes from about 0.01 molar% to about 25 molar% of the one or more C4 to C14 carboxylic acids. Suitably, the amount is from about 0.1 molar% to about 10 molar%. Amounts of 0.2, 0.5, 0.75, 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 molar% are also envisioned within the invention.

Suitably, the ester composition comprises one or more esters of an alcohol and three or more carboxylic acids, for example four carboxylic acids. Suitably, the ester composition comprises esters of an alcohol and four or fewer carboxylic acids. Suitably, the ester composition comprises esters of an alcohol and three or fewer carboxylic acids, for example three carboxylic acids. Suitably, the ester composition consists of esters of an alcohol and three or fewer carboxylic acids.
Suitably, there is provided an ester composition, wherein the ester composition comprises one or more esters derived from a reaction of:

(a) one or more alcohols selected from the group consisting of:
(i) glycerol; and
(ii) ethylene glycol; and

(b) two or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.

Suitably, one of the, or each, alcohol comprises glycerol. Suitably, the composition comprises esters of a single alcohol (a). Suitably, the alcohol (a) comprises glycerol. Suitably, the alcohol (a) consists of glycerol.

Suitably, the carboxylic acids (b) comprise a branched C6 to C12 carboxylic acid. Suitably, the acids (b) comprise a branched C7 to C9 carboxylic acid. Suitably, the carboxylic acids (b) comprise a branched C8 carboxylic acid. Suitably, the carboxylic acids (b) comprise 2-ethylhexanoic acid.

Suitably, the ester composition has dielectric properties. Suitably, the ester composition is suitable for use as a dielectric fluid. Suitably, the ester composition is suitable for use as a dielectric fluid without the need to be combined with a pour point depressant. Alternatively, the ester composition is suitable for use as a dielectric fluid with a pour point depressant.

Suitably, the ester composition comprises a triester. Suitably, the ester composition comprises a glycerol triester. The ester may comprise a mono ester and/or diester.

Suitably the ester composition comprises more than one different triester. Suitably the ester composition comprises more than two different triesters.

Suitably, the ester composition comprises one or more esters formed from the reaction of carboxylic acids with an alcohol having three hydroxyl groups.
Suitably, the ester composition comprises a mixed ester.

Suitably, as used herein, the term “mixed ester” includes: (i) an ester in which the constituent acids in an ester molecule comprise two or more acids.

Suitably, the ester composition comprises a mixed ester composition.

Suitably, as used herein, the term “mixed ester composition” includes: (i) a mixed ester (as defined above); (ii) an ester composition comprising two or more different esters; and (iii) a combination of (i) and (ii).

The ester composition may comprise a mixed ester in which the constituent acids in an ester molecule comprise three acids.

Suitably the ester composition comprises two or more different mixed esters.

The ester composition suitably comprises two or more different esters. The ester composition suitably comprises three or more different esters. The ester composition suitably comprises four or more different esters.

Suitably, the ester composition comprises esters formed from the reaction of an alcohol with two or more carboxylic acids wherein at least one of said carboxylic acids is a linear chain acid.

Suitably, the ester composition comprises esters formed from the reaction of an alcohol with two or more carboxylic acids wherein one of said carboxylic acids is a branched carboxylic acid and the other of said carboxylic acids is/are linear chain carboxylic acids.

Suitably, the ester composition comprises esters formed from the reaction of an alcohol with a mixture of two or more carboxylic acids (b). Suitably, the ester composition comprises esters formed from the reaction of an alcohol with a mixture of three or more carboxylic acids (b).
Suitably, the ester composition comprises esters formed from the reaction of an alcohol with two or more carboxylic acids each selected from the group consisting of C7-C12 carboxylic acids.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 to C12 carboxylic acid having one or more C1 side groups.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 to C12 carboxylic acid having one or more C2 side groups.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 to C12 carboxylic acid wherein said acid comprises a backbone having branching at the C2 position.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 to C12 carboxylic acid having a C6 backbone.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 carboxylic acid having a C6 backbone and a C2 side group.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 carboxylic acid having a C6 backbone and a C2 side group at the C2 position of the backbone.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a branched C8 carboxylic acid.

Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with 2-ethylhexanoic acid.
The ester composition may comprise one or more esters formed from the reaction of an alcohol with a branched C₈ to C₁₂ carboxylic acid wherein said acid comprises a backbone having branching at the C₃ position.

The ester composition may comprise one or more esters formed from the reaction of an alcohol with a branched C₈ to C₁₂ carboxylic acid wherein said acid comprises a backbone having branching at the C₅ position.

The ester composition may comprise one or more esters formed from the reaction of an alcohol with a branched C₉ to C₁₂ carboxylic acid having a C₆ to C₈ backbone.

The ester composition may comprise one or more esters formed from the reaction of an alcohol with a branched C₈ to C₁₂ carboxylic acid having a C₆ backbone and one or more C₁ side groups.

The ester composition may comprise one or more esters formed from the reaction of an alcohol with a branched C₈ to C₁₂ carboxylic acid having a C₆ backbone and C₁ side groups at the C₃ and/or C₅ positions of the backbone.

The ester composition may comprise one or more esters formed from the reaction of an alcohol with a branched C₉ carboxylic acid.

The ester composition may comprises one or more esters formed from the reaction of an alcohol with 3,5,5-trimethylhexanoic acid.

The ester composition may comprises esters formed from the reaction of an alcohol with an acid mixture comprising two or more branched acids, for example 3,5,5-trimethylhexanoic acid and 2-ethylhexanoic acid.

Suitably, the ester composition comprises esters formed from the reaction of an alcohol with a linear C₇ carboxylic acid.
Suitably, the ester composition comprises one or more esters formed from the reaction of an alcohol with a linear C12 carboxylic acid.

Suitably, the ester composition comprises esters formed from the reaction of an alcohol (a) with:

- a branched C8 carboxylic acid; and
- a linear C12 carboxylic acid.

Suitably, the ester composition comprises esters formed from the reaction of an alcohol (a) with:
- a linear C7 carboxylic acid;
- a branched C8 carboxylic acid; and
- a linear C12 carboxylic acid.

Suitably, the ester composition comprises one or more esters formed from the reaction of one or more carboxylic acids with a single alcohol (a) selected from the group consisting of ethylene glycol and glycerol.

Suitably, the ester composition comprises one or more esters formed from the reaction of carboxylic acids with glycerol.

Suitably, the ester composition consists of one or more esters formed from the reaction of carboxylic acids with glycerol.

Suitably, there is provided an ester composition, wherein the ester composition comprises one or more esters of:

(a) glycerol; and
(b) one or more C4 to C14 carboxylic acids wherein one of said acids is 2-Ethylhexanoic acid.
Suitably, there is provided an ester composition, wherein the ester composition comprises a single ester of:

(a) glycerol; and

(b) 2-Ethylhexanoic acid.

Suitably, there is provided an ester composition, wherein the ester composition comprises esters of:

(a) glycerol; and

(b) two or more C4 to C14 carboxylic acids wherein one of said acids is 2-ethylhexanoic acid.

Suitably, the carboxylic acids (b) comprise a linear acid. Suitably, the carboxylic acids (b) comprise a linear C4 to C14 carboxylic acid. Suitably, the carboxylic acids (b) comprise a linear C7 to C14 carboxylic acid.

Suitably, the carboxylic acids (b) comprise a linear C10 to C14 carboxylic acid. Suitably, the carboxylic acids (b) comprise a linear C11 to C13 carboxylic acid. Suitably, the carboxylic acids (b) comprise a linear C12 carboxylic acid. Suitably, the carboxylic acids (b) comprise dodecanoic acid.

Suitably, there is provided an ester composition, wherein the ester composition comprises esters of:

(a) one or more alcohols selected from the group consisting of:

(i) glycerol; and

(ii) ethylene glycol; and

(b) two or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched C6 to C12 carboxylic acid and wherein at least one of said acids is a linear C4 to C14 carboxylic acid.
Suitably, there is provided an ester composition, wherein the ester composition comprises esters of:
(a) glycerol; and
(b) two or more C₄ to C₁₄ carboxylic acids wherein one of said acids is 2-ethylhexanoic acid and one of said acids is dodecanoic acid.

Suitably, the ester composition comprises esters of an alcohol and three carboxylic acids.

Suitably, the carboxylic acids (b) comprise a linear C₆ to C₈ carboxylic acid. Suitably, the carboxylic acids (b) comprise a linear C₇ carboxylic acid.

Suitably, there is provided an ester composition, wherein the ester composition comprises esters of:
(a) one or more alcohols selected from the group consisting of:
   (i) glycerol; and
   (ii) ethylene glycol; and
(b) three C₄ to C₁₄ carboxylic acids wherein at least one of said acids is a branched C₆ to C₁₂ carboxylic acid and wherein at least one of said acids is a linear C₄ to C₁₄ carboxylic acid.

Suitably, the ester composition is substantially free of esters of alcohol and a C₈ linear carboxylic acid. Suitably, the ester composition is substantially free of esters of alcohol and a C₁₀ linear acid.

Suitably, the ester composition consists of esters formed from the reaction of glycerol with an acid mixture consisting of:
a linear C₇ carboxylic acid;
a branched C₈ carboxylic acid;
and a linear C₁₂ carboxylic acid.
Suitably, the ester composition consists of esters formed from the reaction of glycerol with an acid mixture consisting of:

- a branched C8 carboxylic acid; and
- a linear C12 carboxylic acid.

Suitably, there is provided an ester composition, wherein the ester composition comprises esters of:

(a) glycerol; and

(b) 2-ethylhexanoic acid, dodecanoic acid and optionally heptanoic acid;

wherein the ester composition is prepared by reacting glycerol with a mixture of said acids.

Suitably, there is provided an ester composition, wherein the ester composition consists of esters of:

(a) glycerol; and

(b) 2-ethylhexanoic acid, dodecanoic acid and optionally heptanoic acid;

wherein the ester composition is prepared by reacting glycerol with a mixture of said acids.

Suitably, according to the present invention there is provided an ester composition, wherein the ester composition comprises esters of:

(a) glycerol; and

(b) 2-ethylhexanoic acid, optionally dodecanoic acid and optionally heptanoic acid; and

wherein the ester composition is prepared by reacting glycerol with an acid mixture and wherein said acid mixture comprises said acids in the following molar percentages of said acid mixture:
0-40% heptanoic acid;
40-100% 2-ethylhexanoic acid; and
0-35% dodecanoic acid.

Surprisingly it has been found that an ester prepared from glycerol and one or more carboxylic acids comprising a branched carboxylic acid may have properties advantageous for use as a dielectric fluid, such as for example a dynamic viscosity of less than 20 cP at 40°C.

Surprisingly it has been found that an ester prepared from glycerol and carboxylic acids comprising a branched carboxylic acid in combination with a linear C12 carboxylic acid may have properties advantageous for use as a dielectric fluid and may obviate the need to use other carboxylic acids to prepare an ester suitable for use as a dielectric fluid.

The ester composition may comprise alcohol and/or acids as impurities. Suitably, the ester composition is substantially free of alcohol and/or acids.

Suitably, the ester composition has a viscosity of 35cP or less at 40°C. Suitably, the ester composition has a viscosity of 30cP or less at 40°C. Suitably, the ester composition has a viscosity of 25cP or less at 40°C. Suitably, the ester composition has a viscosity of 20cP or less at 40°C. Suitably, said viscosity comprises dynamic viscosity. Suitably, said viscosity comprises a viscosity measured using a Brookfield DV-I Prime Viscometer.

Suitably, the ester composition has a pour point of -20°C or less. Suitably, the ester composition has a pour point of -30°C or less. Suitably, the ester composition has a pour point of -40°C or less. Suitably, the ester composition has a pour point of -50°C or less.

Suitably the ester composition has a measured pour point of -31°C to -49°C or lower when said pour point is measured according to the method of ISO 3016.
Suitably, the ester composition has a COC Fire point of 250°C or higher. Suitably, the ester composition has a COC Fire point of 260°C or higher. Suitably, the ester composition has a COC Fire point of 270°C or higher. Suitably, said COC Fire point is measured according to the method of ISO 2592.

The ester composition may comprise any feature as described in relation to the third aspect.

According to a second aspect of the present invention there is provided a dielectric fluid composition comprising:
(I) an ester composition, wherein the ester composition comprises one or more esters derived from a reaction of:

(a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and
(b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid; and
(II) one or more additives.

Suitably, there is provided a dielectric fluid composition comprising:

(I) an ester composition, wherein the ester composition comprises one or more esters derived from a reaction of: (a) one or more alcohols selected from the group consisting of:
(i) glycerol; and
(ii) ethylene glycol; and

(b) two or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid; and
(II) one or more additives.
Suitably, said additives (II) are selected from the group consisting of antioxidants, metal deactivators and pour point depressants.

Suitably, the ester composition (I) comprises an ester composition according to the first aspect. Suitably, the ester composition (I) consists of an ester composition according to the first aspect.

Suitably, the dielectric fluid composition comprises an ester composition comprising a single ester, wherein the ester is derived from the reaction of glycerol with 2-ethylhexanoic acid.

Suitably, the one or more C4 to C14 carboxylic acids comprise a combination of 2-ethylhexanoic acid and a branched C9 carboxylic acid, such as, for example, 3,5,5-trimethylhexanoic acid; or a combination of 2-ethylhexanoic acid, a linear C8 carboxylic acid and a linear C10 carboxylic acid.

Suitably, the amount of the branched C9 carboxylic acid, or of the combined linear C8 and C10 carboxylic acids, constitutes from about 0.01 molar% to about 25 molar% of the one or more C4 to C14 carboxylic acids. Suitably, the amount is from about 0.1 molar% to about 10 molar%. Amounts of 0.2, 0.5, 0.75, 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 molar% are also envisioned within the invention.

Suitably, the dielectric fluid composition comprises said ester composition (I) in an amount of at least 95% by weight of the dielectric fluid composition. Suitably, the dielectric fluid composition comprises said ester composition (I) in an amount of at least 96% by weight of the composition, for example in an amount of at least: 97%, 98% or 99% by weight of the composition. Suitably, the dielectric fluid composition comprises said ester composition (I) in an amount of at least 99.5% by weight of the composition.
Suitably, the dielectric fluid composition comprises said additives (II) in the following amounts:

one or more antioxidants in a total amount of 0.0001% to 1% by weight of the composition;

one or more metal deactivators in a total amount of 0.0001% to 1% by weight of the composition; and

one or more pour point depressants in a total amount of 0% to 1% by weight of the composition.

Suitably, the dielectric fluid composition comprises an antioxidant in an amount of at least 0.0001% by weight of the composition. Suitably, the dielectric fluid composition comprises an antioxidant in an amount of at least 0.001% by weight of the composition. Suitably, the dielectric fluid composition comprises an antioxidant in an amount of at least 0.01% by weight of the composition. Suitably, the dielectric fluid composition comprises an antioxidant in an amount of at least 0.1% by weight of the composition. Suitably, the dielectric fluid composition comprises an antioxidant in an amount of at least 0.25% by weight of the composition, for example in an amount of 0.25% by weight of the composition.

Suitably, the antioxidant comprises a phenolic antioxidant. Suitably, the antioxidant comprises a sterically hindered phenolic antioxidant. The antioxidant may comprise BHT and/or BHA.

Suitably, the dielectric fluid composition comprises a metal deactivator in an amount of at least 0.0001% by weight of the composition. Suitably, the dielectric fluid composition comprises a metal deactivator in an amount of at least 0.001% by weight of the composition. Suitably, the dielectric fluid composition comprises a metal deactivator in an amount of at least 0.002% by weight of the composition. Suitably, the dielectric fluid composition comprises a metal deactivator in an amount of at least 0.005% by weight of the composition, for example in an amount of 0.005% by weight of the composition.
Suitably, the metal deactivator comprises a tolutriazole derivative. Suitably, the metal deactivator comprises Irgamet 39™ available from BASF.

Suitably, the dielectric fluid composition comprises one or more additives (II) selected from the group consisting of antioxidants and metal deactivators.

The dielectric fluid composition may be substantially free from pour point depressant. Alternatively, the dielectric fluid composition may comprise a pour point depressant. Suitably, the ester composition (I) is suitable for use as a dielectric fluid without the need to be combined with a pour point depressant.

Suitably, the dielectric fluid composition comprises an ester composition (I) and additives (II) in a combined amount of at least 95% by weight of the composition.

Suitably, the dielectric fluid composition comprises an ester composition (I) and additives (II) in a combined amount of at least 99% by weight of the composition.

Suitably, the dielectric fluid composition comprises an ester composition, an antioxidant and a metal deactivator in a combined amount of at least 99% by weight of the composition.

Suitably, the dielectric fluid composition comprises an ester composition, an antioxidant and a metal deactivator in a combined amount of at least 99.9% by weight of the composition. Suitably, the dielectric fluid composition consists of an ester composition, an antioxidant and a metal deactivator.
The dielectric fluid composition may comprise alcohol and/or acids as impurities. Suitably, the dielectric fluid composition is substantially free of alcohol and/or acids.

Suitably, the dielectric fluid composition has a viscosity of 35cP or less at 40°C. Suitably, the dielectric fluid composition has a viscosity of 30cP or less at 40°C. Suitably, the dielectric fluid composition has a viscosity of 25cP or less at 40°C. Suitably, the dielectric fluid composition has a viscosity of 20cP or less at 40°C. Suitably, said viscosity comprises dynamic viscosity. Suitably, said viscosity comprises a viscosity measured using a Brookfield DV-I Prime Viscometer.

Suitably, the dielectric fluid composition has a pour point of -20°C or less. Suitably, the dielectric fluid composition has a pour point of -30°C or less. Suitably, the dielectric fluid composition has a pour point of -40°C or less. Suitably, the dielectric fluid composition has a pour point of -50°C or less.

Suitably the dielectric fluid composition has a measured pour point of -31°C to -49°C or lower when said pour point is measured according to the method of ISO 3016.

Suitably, the dielectric fluid composition has a COC Fire point of 250°C or higher. Suitably, the dielectric fluid composition has a COC Fire point of 260°C or higher. Suitably, the dielectric fluid composition has a COC Fire point of 270°C or higher. Suitably, said COC Fire point is measured according to the method of ISO 2592.

The dielectric fluid composition may comprise an ester composition having any feature as described in relation to the first aspect and/or third aspect. Suitably, the dielectric fluid composition comprises an ester composition according to the first aspect.

The dielectric fluid composition may comprise an ester manufactured according to the method of the third aspect. The dielectric fluid composition may comprise any feature as described in relation to the fourth aspect.
According to a third aspect of the present invention there is provided a method of manufacturing an ester composition, wherein the method comprises forming one or more esters by reacting:

(a) one or more alcohols selected from the group consisting of C$_2$ and C$_3$ polyols; and
(b) one or more C$_4$ to C$_{14}$ carboxylic acids wherein at least one of said acids is a branched acid.

Suitably, alcohol (a) is selected from the group consisting of:
(i) glycerol; and
(ii) ethylene glycol.

Suitably, the alcohol (a) is glycerol and the carboxylic acid is 2-ethylhexanoic acid.

Suitably, the method comprises a method of manufacturing an ester according to the first aspect. The ester composition may comprise any feature as described in relation to the first aspect.

Suitably, the method comprises forming esters by reacting one or more alcohols (a) and two or more C$_4$ to C$_{14}$ carboxylic acids (b). Suitably, the method comprises forming esters by reacting one or more alcohols and four or fewer C$_4$ to C$_{14}$ carboxylic acids. Suitably, the method comprises forming esters by reacting one or more alcohols and three or fewer C$_4$ to C$_{14}$ carboxylic acids.

Suitably, there is provided a method of manufacturing an ester composition, wherein the method comprises forming esters by reacting:

(a) one or more alcohols selected from the group consisting of:
(i) glycerol; and
(ii) ethylene glycol; and
(b) two or more C₄ to C₁₄ carboxylic acids wherein at least one of said acids is a branched acid.

Suitably, the method comprises forming esters by reacting one or more linear chain C₄ to C₁₄ carboxylic acids and one or more branched chain C₄ to C₁₄ carboxylic acids with one or more alcohols.

The method may comprise reacting one or more branched chain C₈ and/or C₉ carboxylic acids with one or more alcohols. The method may for example comprise reacting an alcohol with an acid mixture comprising two or more branched acids, for example 3,5,5-trimethylhexanoic acid and 2-ethylhexanoic acid (branched C₉ and C₈ acids, respectively).

Suitably, the method comprises forming esters by reacting:

(a) one or more alcohols selected from the group consisting of:
    (i) glycerol; and
    (ii) ethylene glycol; and
(b) two or more C₄ to C₁₄ carboxylic acids wherein at least one of said acids is a linear chain acid and wherein at least one of said acids is a branched chain acid.

Suitably, the method may comprise reacting 2-ethylhexanoic acid, a linear C₈ carboxylic acid and a linear C₁₀ carboxylic acid with one or more alcohols.

Suitably, the amount of branched C₉ carboxylic acid, or of the combined linear C₈ and C₁₀ carboxylic acids, constitutes from about 0.01 molar% to about 25 molar% of the one or more C₄ to C₁₄ carboxylic acids. Suitably, the amount is from about 0.1 molar% to about 10 molar%. Amounts of 0.2, 0.5, 0.75, 1, 2, 3, 4, 5, 6, 7, 8, 9 or 10 molar% are also envisioned within the invention.
Suitably, the method comprises forming esters by reacting carboxylic acids with one alcohol.

Suitably, the method comprises forming esters by reacting an alcohol having three hydroxyl groups with carboxylic acids.

Suitably, the alcohol (a) comprises glycerol.

Suitably, the method comprises forming esters by reacting one alcohol and two or more \( C_4 \) to \( C_{14} \) carboxylic acids. Suitable, the method comprises forming esters by reacting one alcohol and two \( C_4 \) to \( C_{14} \) carboxylic acids. Suitably, the method comprises forming esters by reacting one alcohol and three \( C_4 \) to \( C_{14} \) carboxylic acids.

Suitably, the method comprises forming esters by reacting one or more linear chain \( C_4 \) to \( C_{14} \) carboxylic acids and one or more branched chain \( C_4 \) to \( C_{14} \) carboxylic acids with one alcohol. Suitably, the method comprises forming esters by reacting two or more linear chain \( C_4 \) to \( C_{14} \) carboxylic acids and one branched chain \( C_4 \) to \( C_{14} \) carboxylic acid with one alcohol.

Suitably, the method comprises forming esters by reacting:

(a) one or more alcohols selected from the group consisting of:

(i) glycerol; and

(ii) ethylene glycol; and

(b) two \( C_4 \) to \( C_{14} \) carboxylic acids wherein at least one of said acids is a linear chain acid and wherein at least one of said acids is a branched chain acid.

Suitably, the method comprises forming esters by reacting glycerol with carboxylic acids. Suitably, the method comprises forming esters by reacting glycerol with a mixture of carboxylic acids.
Suitably, the method comprises forming esters by reacting:

(a) glycerol; and
(b) two or more C4 to C14 carboxylic acids wherein at least one of said acids is a linear chain acid and wherein at least one of said acids is a branched chain acid.

Suitably, one of said acids (b) is heptanoic acid. Suitably, one of said acids (b) is 2-ethylhexanoic acid. Suitably, one of said acids (b) is dodecanoic acid.

Suitably, the method comprises forming one or more esters by reacting:

(a) glycerol; and
(b) 2-ethylhexanoic acid.

Suitably, the method comprises forming one or more esters by reacting:

(a) glycerol; and
(b) an acid mixture comprising 2-ethylhexanoic acid and dodecanoic acid.

Suitably, the method comprises forming one or more esters by reacting:

(a) glycerol; and
(b) an acid mixture comprising 2-ethylhexanoic acid, dodecanoic acid and heptanoic acid.

Suitably, the method comprises forming one or more esters by reacting a mixture of alcohol and carboxylic acids in which:

(a) glycerol is the sole alcohol; and
(b) 2-ethylhexanoic acid, dodecanoic acid and heptanoic acid are the sole carboxylic acids.

Suitably, the method comprises forming one or more esters by reacting a mixture of alcohol and carboxylic acids in which:

(a) glycerol is the sole alcohol; and
(b) 2-ethylhexanoic acid and dodecanoic acid are the sole carboxylic acids.

Suitably, the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises at least 40% of a C₈ acid, suitably 2-ethylhexanoic acid, as a molar percentage of the acid mixture, for example at least 50%.

Suitably, the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises 40-100% of a C₈ acid as a molar percentage of the acid mixture, for example 50-90%.

Suitably, the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises at least 5% of a C₁₂ acid, suitably dodecanoic acid, as a molar percentage of the acid mixture, for example at least 10%.

Suitably, the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises no more than 35% by weight of a C₁₂ acid, suitably dodecanoic acid, as a molar percentage of the acid mixture.

Suitably, the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises 10-35% of a C₁₂ acid as a molar percentage of the acid mixture.

The method may comprise forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises at least 5% of a C₇ acid, suitably heptanoic acid, as a molar percentage of the acid mixture, for example at least 15%.
Suitably, the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises 0-40% of a C7 acid as a molar percentage of the acid mixture.

Suitably, the method comprises forming one or more esters by reacting glycerol with an acid mixture, wherein said acid mixture comprises acids in the following molar percentages:

0-40% C7 acid;
40-100% C8 acid; and
0-35% C12 acid.

Suitably, the method comprises forming esters by reacting glycerol with an acid mixture, wherein said acid mixture comprises acids in the following molar percentages:

0-40% linear C7 acid;
40-100% branched C8 acid; and
0-35% branched C12 acid.

Suitably, according to the present invention there is provided a method of manufacturing esters by reacting glycerol with an acid mixture, wherein said acid mixture comprises acids in the following molar percentages:

0-40% heptanoic acid;
40-100% 2-ethylhexanoic acid; and
0-35% dodecanoic acid.

Suitably, the method comprises forming triesters. Suitably, the method comprises forming glycerol triesters.

Suitably, the method comprises reacting an alcohol with an excess of carboxylic acids.
Suitably, the method comprises reacting an alcohol with carboxylic acids wherein said acids are in excess by an amount of at least 10 molar %. Suitably, the method comprises reacting an alcohol with carboxylic acids wherein said acids are in excess by a amount of at least 20 molar %, for example an excess of 30 molar %.

Suitably, the method comprises refluxing an alcohol and carboxylic acid mixture. Suitably, the method comprises refluxing an acid and carboxylic acid mixture for between 3 and 4 hours. Suitably, the method comprises refluxing an acid and carboxylic acid mixture at a temperature of between 245°C and 255°C, for example between 248°C and 252°C. Suitably, the method comprises refluxing under a nitrogen atmosphere.

Suitably, the method comprises removing water as it is formed. Suitably, the method comprises removing excess acid following the reflux stage. Suitably, the method comprises neutralising the reaction mixture following the reflux stage. Suitably, the method comprises treating the ester composition. Suitably, the method comprises adding alumina. Suitably, the method comprises adding Fuller’s earth powders. Suitably, the method comprises filtering the ester composition. Suitably, the method comprises adding an antioxidant. The method may comprise adding an antioxidant with heating, suitably prior to filtering.

According to a fourth aspect of the present invention there is provided a method of manufacturing a dielectric fluid composition comprising an ester composition, wherein the method comprises combining an ester composition (I) with an additive (II) wherein said ester composition (I) comprises one or more esters derived from the reaction of:

(a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and
(b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.
Suitably, alcohol (a) is selected from the group consisting of:

(i) glycerol; and

(ii) ethylene glycol.

Suitably, alcohol (a) is glycerol and the carboxylic acid is 2-ethylhexanoic acid.

Suitably, the ester composition (I) comprises an ester according to the first aspect.

Suitably, the method comprises a method of manufacturing a dielectric fluid according to the second aspect.

Suitably, the method comprises manufacturing an ester (I) according to the method of the third aspect and combining an additive (II) therewith.

Suitably, the additive (II) is selected from the group consisting of antioxidants, metal deactivators and pour point depressants.

Suitably, the method comprises adding an antioxidant. The method may comprise adding an antioxidant with heating. The method may comprise adding an antioxidant prior to filtering of the ester composition. Suitably the method comprises adding a metal deactivator. The method may comprise adding a metal deactivator subsequent to filtering of the ester composition.

The method may comprise any feature as described in relation to the first, second and/or third aspects.

According to a fifth aspect of the present invention there is provided an electrical apparatus comprising an ester composition according to the first aspect and/or a dielectric fluid according to the second aspect and/or an ester composition manufactured according to the method of the third aspect and/or a dielectric fluid composition manufactured according to the method of the fourth aspect.
Suitably, the electrical apparatus comprises a transformer. Suitably, the electrical apparatus comprises a high voltage transformer.

According to a sixth aspect of the present invention there is provided the use of an ester composition according to the first aspect and/or an ester composition manufactured according to the method of the second aspect as a dielectric fluid.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be illustrated by way of the following examples, which are intended to be exemplary only and in no way limiting upon the scope of the invention.

Example 1

An ester composition suitable for use as a dielectric fluid was prepared by forming esters by reacting glycerol with a mixture of 2-ethylhexanoic acid (2EHA) and dodecanoic acid (C12).

Approximately 900g of ester composition was prepared according to the following method:

170g glycerol was combined with 934.5g 2-ethylhexanoic acid (2EHA) and 144.2g dodecanoic acid (C12). The amounts of acids and alcohol were selected such that the acid mixture was present in 30 molar % excess relative to the alcohol and such that the acids were present relative to one another in the molar percentages set out in Table 1.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Molar %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2EHA</td>
<td>90</td>
</tr>
<tr>
<td>C12</td>
<td>10</td>
</tr>
</tbody>
</table>
Esters were then prepared by refluxing glycerol and the acid mixture at between 248-252°C under a nitrogen atmosphere for 4 hours to produce an ester composition. Water was removed as it was formed using Dean-Stark apparatus.

Following completion of the reflux stage excess acid was removed by vacuum distillation, and the acid value, hydroxyl value and colour of the ester composition was determined. The results are presented in Table 3.

The ester composition was then processed further to prepare a dielectric fluid composition.

The ester composition was then stirred at 80°C for one hour in the presence of Alumina in an amount of 1g Alumina for every 0.01 mgKOH/g required to neutralise the reaction mixture to remove any residual acid As well as Fullers’ earth powders F160 (0.45% w/w) and F115FF (0.112% w/w) to clean the sample, and a sterically hindered phenolic antioxidant (0.25% w/w). The composition was then filtered.

A tolutriazole derivative metal deactivator, Irgamet 39, was added to the composition in an amount of 0.005% w/w.

The composition was then degassed for approximately thirty minutes until the moisture content of the composition was below 80ppm.

Electrical and physical testing was performed on the composition according to the test methods given in Table 2. The results are presented in Table 3.
Table 2

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content</td>
<td>IEC 60814</td>
</tr>
<tr>
<td>Acid Value</td>
<td>Modified IEC 62021-2</td>
</tr>
<tr>
<td>Hydroxyl value</td>
<td>IR spectrometer</td>
</tr>
<tr>
<td>Colour</td>
<td>ISO 2211</td>
</tr>
<tr>
<td>Breakdown voltage</td>
<td>IEC 60156</td>
</tr>
<tr>
<td>Viscosity at 40°C</td>
<td>Brookfield Viscometer</td>
</tr>
<tr>
<td></td>
<td>DV-1 Prime</td>
</tr>
<tr>
<td>Density at 20°C</td>
<td>ISO 3675</td>
</tr>
<tr>
<td>COC flash point</td>
<td>ISO 2592</td>
</tr>
<tr>
<td>COC fire point</td>
<td>ISO 2592</td>
</tr>
<tr>
<td>PMCC flash point</td>
<td>ISO 2719</td>
</tr>
<tr>
<td>Pour point</td>
<td>Modified ISO 3016</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Physical and electrical properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content (ppm)</td>
<td>35</td>
</tr>
<tr>
<td>Acid Value (mgKOH/g)</td>
<td>0.009</td>
</tr>
<tr>
<td>Hydroxyl (mgKOH/g)</td>
<td>0.9</td>
</tr>
<tr>
<td>Colour (HU)</td>
<td>41</td>
</tr>
<tr>
<td>Breakdown (kV)</td>
<td>79</td>
</tr>
<tr>
<td>Viscosity at 40°C (cP)</td>
<td>16.4</td>
</tr>
<tr>
<td>Density at 20°C (g/cm³)</td>
<td></td>
</tr>
<tr>
<td>COC flash point (°C)</td>
<td>236</td>
</tr>
<tr>
<td>COC Fire point (°C)</td>
<td>262</td>
</tr>
<tr>
<td>Pour point (°C)</td>
<td>-59</td>
</tr>
</tbody>
</table>

As can be seen from the above the dielectric fluid composition of Example 1 has physical and electrical properties rendering it suitable for use as a dielectric fluid.
Examples 2 to 6

The method of Example 1 was repeated using different ratios of acids with some examples including heptanoic acid (C7) and some excluding dodecanoic acid (C12). All examples used 2-ethylhexanoic acid (2EHA). Example 2 employs 2EHA alone, while Examples 3-5 employ 2EHA and varying amounts of dodecanoic acid, while Example 6 employs 2EHA and amounts of both dodecanoic acid and heptanoic acid.

In each example approximately 900g of ester composition was prepared according to the following method:

Glycerol was combined with ethylhexanoic acid (2EHA), dodecanoic acid (C12) and heptanoic acid (C7) with the amounts of acids and alcohol selected such that the acid mixture was present in 30 molar % excess relative to the alcohol and such that the acids were present relative to one another in the molar percentages set out in Table 4.

<table>
<thead>
<tr>
<th>Example</th>
<th>Acid</th>
<th>Molar %</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C7</td>
<td>90</td>
<td>100</td>
<td>84.9</td>
<td>70</td>
<td>75</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2EHA</td>
<td></td>
<td></td>
<td>15.1</td>
<td>30</td>
<td>25</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In each example esters were then prepared by refluxing glycerol and the acid mixture at between 248-252°C under a nitrogen atmosphere for between 3 and 4 hours to produce an ester composition. Water was removed as it was formed using Dean-Stark apparatus.

Following completion of the reflux stage the ester composition was processed and tested as described in relation to Example 1. The results are presented in Table 5 together with the results of Example 1.
<table>
<thead>
<tr>
<th>Physical and electrical properties</th>
<th>Example</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7 Acid ratio (ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2EHA Water content</td>
<td>90</td>
<td>100</td>
<td>84.9</td>
<td>70</td>
<td>75</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>C12 Acid value (mgKOH/g)</td>
<td>0.009</td>
<td>0.011</td>
<td>0.008</td>
<td>0.007</td>
<td>0.015</td>
<td>0.015</td>
<td></td>
</tr>
<tr>
<td>Hydroxyl (mgKOH/g)</td>
<td>0.9</td>
<td>1.9</td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
<td>0.8</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Colour (HU)</td>
<td>41</td>
<td>366</td>
<td>169</td>
<td>148</td>
<td>28</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Breakdown (kV)</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity at 40°C (cP)</td>
<td>16.4</td>
<td>15.3</td>
<td>16.2</td>
<td>17.7</td>
<td>17.8</td>
<td>14.1</td>
<td></td>
</tr>
<tr>
<td>Density at 20°C (g/cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COC flash point (°C)</td>
<td>236</td>
<td>234</td>
<td>234</td>
<td>246</td>
<td>244</td>
<td>244</td>
<td></td>
</tr>
<tr>
<td>COC Fire point (°C)</td>
<td>262</td>
<td>261</td>
<td>269</td>
<td>278</td>
<td>272</td>
<td>272</td>
<td></td>
</tr>
<tr>
<td>Pour point (°C)</td>
<td>-59</td>
<td>&lt;-60</td>
<td>-52.2</td>
<td>-30</td>
<td></td>
<td>-45</td>
<td></td>
</tr>
</tbody>
</table>

It will be appreciated that preferred embodiments of ester compositions according to the present invention may have physical and electrical properties making them suitable for use in dielectric fluid compositions in electrical apparatus such as for example transformers.

It will be appreciated that preferred embodiments of dielectric fluid compositions according to the present invention may have a viscosity at 40°C which compares favourably to known dielectric fluid compositions.
Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.
CLAIMS

1. A dielectric fluid composition comprising:

(I) an ester composition, wherein the ester composition comprises one or more esters derived from a reaction of:
(a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and
(b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid; and
(II) one or more additives.

2. A dielectric fluid composition according to claim 1, wherein the ester composition comprises a single ester, wherein the ester is derived from the reaction of glycerol with 2-ethylhexanoic acid.

3. A dielectric fluid composition according to claim 1, wherein the one or more C4 to C14 carboxylic acids comprise 2-ethylhexanoic acid and a branched C9 carboxylic acid.

4. A dielectric fluid composition according to claim 1, wherein the one or more C4 to C14 carboxylic acids comprise 2-ethylhexanoic acid, a linear C8 carboxylic acid and a linear C10 carboxylic acid.

5. A dielectric fluid composition according to claim 3 or claim 4, wherein the amount of the branched C9 carboxylic acid, or of the combined linear C8 and C10 carboxylic acids, constitutes from about 0.01 molar% to about 25 molar% of the one or more C4 to C14 carboxylic acids.

6. A dielectric fluid according to any preceding claim, wherein said additives (II) are selected from the group consisting of antioxidants, metal deactivators and pour point depressants.

7. A dielectric fluid according to any preceding claim, wherein the dielectric fluid composition comprises an ester composition (I) and additives (II) in a combined amount of at least 99% by weight of the composition.
8. A dielectric fluid according to any preceding claim, wherein the dielectric fluid composition comprises an antioxidant in an amount of at least 0.0001% by weight of the composition and/or a metal deactivator in an amount of at least 0.0001% by weight of the composition.

9. A dielectric fluid according to claim 8, wherein the antioxidant comprises a sterically hindered phenolic antioxidant and/or wherein the metal deactivator comprises a tolutriazole derivative.

10. A dielectric fluid according to any preceding claim, wherein the dielectric fluid composition comprises a pour point depressant.

11. A dielectric fluid according to any preceding claim, wherein the ester composition comprises esters of an alcohol and three acids and wherein the alcohol (a) comprises glycerol and wherein one of said acids (b) is heptanoic acid, one of said acids (b) is 2-ethylhexanoic acid and one of said acids (b) is dodecanoic acid.

12. An ester composition, wherein the ester composition comprises one or more esters of: (a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and (b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.

13. An ester composition according to claim 12, wherein the composition comprises one or more esters of a single alcohol (a).

14. An ester composition according to any of claim 12 or claim 13, wherein alcohol (a) is selected from the group consisting of: (i) glycerol; and (ii) ethylene glycol.

15. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises a single ester, wherein the ester is derived from the reaction of glycerol with 2-ethylhexanoic acid.
16. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters of an alcohol and two or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.

17. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with two or more carboxylic acids wherein at least one of said carboxylic acids is a linear chain acid.

18. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with two or more carboxylic acids wherein one of said carboxylic acids is a branched carboxylic acid and the other of said carboxylic acids is/are linear chain carboxylic acids.

19. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with two or more carboxylic acids each selected from the group consisting of C7-C12 carboxylic acids.

20. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters of an alcohol and three or fewer carboxylic acids.

21. An ester composition according to any of claims 12 to 14, 16, 19 or 20, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with 2-ethylhexanoic acid and a branched C9 carboxylic acid.

22. An ester composition according to any of claims 12 to 14 or 17-20, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with 2-ethylhexanoic acid, a linear C8 carboxylic acid and a linear C10 carboxylic acid.

23. An ester composition according to claim 21 or claim 22, wherein the amount of the branched C9 carboxylic acid, or of the combined linear C8 and C10 carboxylic acids, constitutes from about 0.01 molar% to about 25 molar% of the one or more C4 to C14 carboxylic acids.
24. An ester composition according to any of claims 12 to 14 or 17-20, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with a linear C7 carboxylic acid and/or esters formed from the reaction of an alcohol with a linear C12 carboxylic acid.

25. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters formed from the reaction of an alcohol with 2-ethylhexanoic acid.

26. An ester composition according to any of claims 12 to 25, wherein the ester composition comprises one or more esters formed from the reaction of carboxylic acids with glycerol.

27. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters of:
   (a) glycerol; and
   (b) one or more C4 to C14 carboxylic acids wherein one of said acids is 2-ethylhexanoic acid.

28. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises esters of:
   (a) glycerol; and
   (b) 2-ethylhexanoic acid, dodecanoic acid and optionally heptanoic acid;
   wherein the ester composition is prepared by reacting glycerol with a mixture of said acids.

29. An ester composition according to any of claims 12 to 14 and 17-20, wherein the ester composition consists of esters of:
   (a) glycerol; and
   (b) 2-ethylhexanoic acid, dodecanoic acid and optionally heptanoic acid;
   wherein the ester composition is prepared by reacting glycerol with a mixture of said acids.

30. An ester composition according to any of claims 12 to 14, wherein the ester composition comprises one or more esters of:
   (a) glycerol; and
   (b) 2-ethylhexanoic acid, optionally dodecanoic acid and optionally heptanoic acid; and
wherein the ester composition is prepared by reacting glycerol with an acid mixture and wherein said acid mixture comprises said acids in the following molar percentages of said acid mixture:
0-40% heptanoic acid;
40-100% 2-ethylhexanoic acid; and
0-35% dodecanoic acid.

31. An ester composition according to any of claims 12 to 14, wherein one of said acids (b) is heptanoic acid, one of said acids (b) is 2-ethylhexanoic acid and one of said acids (b) is dodecanoic acid.

32. A dielectric fluid composition according to any of claims 1 to 11, wherein the ester composition (I) comprises an ester composition according to any of claims 12 to 31.

33. A method of manufacturing an ester composition, wherein the method comprises forming one or more esters by reacting:
(a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and
(b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.

34. A method according to claim 33, wherein the method comprises manufacturing an ester composition according to any of claims 12 to 31.

35. A method according to claim 33 or 34, wherein alcohol (a) is selected from the group consisting of:
(i) glycerol; and
(ii) ethylene glycol.

36. A method according to any of claims 33 to 35, wherein the method comprises forming a single ester, wherein the ester is derived from the reaction of glycerol with 2-ethylhexanoic acid.

37. A method according to any of claims 33 to 35, wherein the method comprises forming one or more esters by reacting 2-ethylhexanoic acid and a branched C9 carboxylic acid.
38. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting one or more linear chain C4 to C14 carboxylic acids and one or more branched chain C4 to C14 carboxylic acids with one alcohol.

39. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting 2-ethylhexanoic acid, a linear C8 carboxylic acid and a linear C10 carboxylic acid.

40. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting two or more linear chain C4 to C14 carboxylic acids and one branched chain C4 to C14 carboxylic acid with one alcohol.

41. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting:
   (a) glycerol; and
   (b) two or more C4 to C14 carboxylic acids wherein at least one of said acids is a linear chain acid and wherein at least one of said acids is a branched chain acid.

42. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises at least 40% of a C8 acid as a molar percentage of the acid mixture.

43. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises at least 5% of a C12 acid as a molar percentage of the acid mixture.

44. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting an alcohol with an acid mixture, wherein said acid mixture comprises at least 5% of a C7 acid as a molar percentage of the acid mixture.

45. A method according to any of claims 33 to 36, wherein the method comprises forming one or more esters by reacting:
   (a) glycerol; and
   (b) an acid mixture comprising 2-ethylhexanoic acid, dodecanoic acid and heptanoic acid.
46. A method according to claim 45, wherein the method comprises forming one or more esters by reacting:
(a) glycerol; and
(b) an acid mixture comprising at least 40% of 2-ethylhexanoic acid, at least 5% of dodecanoic acid and at least 5% of heptanoic acid as a molar percentage of the acid mixture.

47. A method of manufacturing a dielectric fluid composition comprising an ester composition, wherein the method comprises combining an ester composition (I) with an additive (II) wherein said ester composition (I) comprises an ester derived from the reaction of:
(a) one or more alcohols selected from the group consisting of C2 and C3 polyols; and
(b) one or more C4 to C14 carboxylic acids wherein at least one of said acids is a branched acid.

48. A method according to claim 47, wherein the method comprises forming a single ester, wherein the ester is derived from the reaction of glycerol with 2-ethylhexanoic acid.

49. A method according to claim 47 or claim 48, wherein the dielectric fluid composition comprises one or more additives (II) selected from the group consisting of antioxidants, metal deactivators and pour point depressants.

50. A method according to any of claims 47 to 49, wherein the ester composition (I) comprises an ester according to any of claims 12 to 31 and/or wherein the method comprises a method of manufacturing a dielectric fluid according to any of claims 1 to 11 or claim 32.

51. A method according to any of claims 47 to 50, wherein the method comprises manufacturing an ester (I) according to the method of any of claims 25 to 35 and combining an additive (II) therewith.

52. An electrical apparatus comprising an ester composition according to any of claims 12 to 31 and/or a dielectric fluid according to any of claims 1 to 11 or claim 32 and/or an ester composition manufactured according to the method of any of claims 33 to 46 and/or a dielectric fluid composition manufactured according to the method of any of claims 47 to 51.
53. The use of an ester composition according to any of claims 12 to 31 and/or an ester composition manufactured according to the method of any of claims 33 to 46 as a dielectric fluid.

54. A use according to claim 53, wherein the ester composition comprises a single ester, wherein the ester is derived from the reaction of glycerol with 2-ethylhexanoic acid.

**Patents Act 1977: Search Report under Section 17**

**Documents considered to be relevant:**

<table>
<thead>
<tr>
<th>Category</th>
<th>Relevant to claims</th>
<th>Identity of document and passage or figure of particular relevance</th>
</tr>
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</table>
| X        | 1-55               | WO 97/22572 A1  
Cooper Industries - see e.g. claims 19-23 |
| X        | 1-55               | WO 2006/040888 A1  
Japan Energy - see WPI abstract number 2006-306261 |
| X        | 1-55               | US 2010/0216678 A1  
Patil - see e.g. the abstract and claims |
| X        | 1-55               | US 2008/0033201 A1  
Hof - see e.g. the abstract and claims |
| X        | 1-55               | EP 1688476 A1  
Chevron Oronite - see e.g. claim 9 |
| X        | 1-55               | JP 2008280500 A  
New Japan Chem - see WPI abstract number 2008-N63232 |
| X        | 1-55               | JP 2000256688 A  
Kyodo Yushi - see WPI abstract number 2001-010845 |
| X        | 1-55               | JP H04314796 A  
Nippon Oils & Fats - see WPI abstract number 1992-419618 |
| X        | 1-55               | JP H0388892 A  
Kao Corp - see WPI abstract number 1991-153165 |

**Categories:**

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<tr>
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<td>Document indicating lack of novelty or inventive step</td>
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<tr>
<td>Y</td>
<td>Document indicating lack of inventive step if combined with one or more other documents of same category.</td>
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<td>&amp;</td>
<td>Member of the same patent family</td>
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<td>A</td>
<td>Document indicating technological background and/or state of the art.</td>
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<td>P</td>
<td>Document published on or after the declared priority date but before the filing date of this invention.</td>
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**Field of Search:**
Search of GB, EP, WO & US patent documents classified in the following areas of the UKC:

Worldwide search of patent documents classified in the following areas of the IPC
C10M; H01B

The following online and other databases have been used in the preparation of this search report
EPODOC, WPI

**International Classification:**

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