

COMPOSITION

The present invention relates to a composition. In particular the present invention relates to fuel compositions having reduced nitrogen oxide emissions when combusted.

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As discussed in US 7,491,247 environmental considerations and government regulations have increased the need to reduce nitrogen oxide (NO_x) production. Nitrogen oxides comprise a major irritant in smog and are believed to contribute to tropospheric ozone which is a known threat to health. Relatively high flame temperatures reached in internal combustion engines, for example diesel-fuelled engines, increase the tendency for the production of nitrogen oxides (NO_x). These are formed from both the combination of nitrogen and oxygen in the combustion chamber and from the oxidation of organic nitrogen species in the fuel.

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Various methods for reducing NO_x production include the use of catalytic converters, engine timing changes, exhaust recirculation, and the burning of "clean" fuels. These methods are generally too expensive and/or too complicated to be placed in widespread use. The rates at which NO_x are formed is related to the flame temperature; a small reduction in flame temperature can result in a large reduction in the production of nitrogen oxides.

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It has been shown that introducing water into the combustion zone can lower the flame temperature and thus lower NO_x production, however; the direct injection of water requires costly and complicated changes in engine design. Further attempts to use water to reduce flame temperature include the use of aqueous fuels, i.e., incorporating both water and fuel into an emulsion. Problems that may occur from long-term use of aqueous fuels include precipitate depositions include coalescing ionic species resulting in filter plugging and inorganic post combustion deposits resulting in turbo fouling. Another problem related to aqueous fuel compositions is that they often require substantial engine modifications, such as the addition of in-line homogenizers, thereby limiting their commercial utility.

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Another method for introducing water into the combustion area is to use fuel emulsions in which water is emulsified into a fuel continuous phase, i.e., invert fuel emulsions. A problem with these invert fuel emulsions is obtaining and maintaining the stability of the emulsion under conventional use conditions. Gravitational phase separation (during

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storage) and high temperature high pressure/shear flow rate phase separation (in a working engine) of these emulsions present the major hurdle preventing their commercial use.

5 DE-A-3229918 teaches the preparation of emulsions of 25 wt. of water in diesel oil using emulsifier which are polyesters of saturated or unsaturated fatty acids having 8-22 carbon atoms. The emulsifiers include polyglycerol esters, sorbitan esters or diacetyltartaric acid esters of glycerol esters of the fatty acids. The emulsifiers are dosed in the fuel compositions in amounts of 0.65 to 1.6 wt.%. The diesel emulsions are taught
10 to be stable for at least 6 months and, as compared with pure diesel oil used in engines, give a better fuel economy, less coke deposition and a lower content of CO and hydrocarbons in the exhaust gas. In such a system, the emulsifier is potentially the most expensive component and dosage at the high levels of this document, such as at 1.6 wt.% would be expensive in use and potentially not commercially viable.

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The present invention addresses the problems associated with the use of fuel emulsion compositions by providing a stable fuel emulsion composition with the beneficial reduction in NOx emissions using commercially viable amounts of emulsifier.

20 The present invention alleviates the problems of the prior art.

In one aspect the present invention provides a fuel composition comprising:

(a) a fuel; and

(b) a polyglycerol ester of a fatty acid;

25 wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols; triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols; tetraglycerol in an amount of 6.0 to 21.0 weight% based on
30 the combined weight of the polyglycerols; pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols; hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols; heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols; octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the
35 polyglycerols; nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined

weight of the polyglycerols; decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

- 5 In one aspect the present invention provides a method for improving the stability of a fuel composition containing (a) fuel and (c) water, the method comprising mixing with the fuel and water, (b) a polyglycerol ester of a fatty acid;
- wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of
- 10 diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols; triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols; tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols; pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols; hexaglycerol in an amount
- 15 of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols; heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols; octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols; nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols; decaglycerol in an amount of 0.0 to 8.0 weight% based on
- 20 the combined weight of the polyglycerols; and unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

- In one aspect the present invention provides a kit for preparing a fuel composition as defined herein, the kit comprising a polyglycerol ester of a fatty acid as described herein;
- 25 together with instructions for use to prepare a fuel composition containing fuel and water.

- In one aspect the present invention provides use of a polyglycerol ester of a fatty acid for improving the stability of a fuel composition containing fuel and water;
- wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid
- 30 comprises a mixture of
- diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols; triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols; tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols; pentaglycerol in an amount of 3.5 to 19.0
- 35 weight% based on the combined weight of the polyglycerols; hexaglycerol in an amount

of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols; heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols; octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols; nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols; decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

We have shown that when a polyglycerol composition is used which has predominantly one polyglycerol present, such as diglycerol or triglycerol, then the polyglycerol composition must be present in a significantly higher amount to provide a fuel/water emulsion which is stable during storage. In contrast we have surprisingly found that having a broad range of polyglycerols present in a polyglycerol composition, and in particular the specific ranges recited herein, then a lower and therefore commercially viable amount of emulsifiers may be used while still providing a fuel and water emulsion which is stable over the period required in use, such as 3 hours. The "flat" distribution of polyglycerols allows for this enhanced effect at low dosages. By flat distribution it is meant that the polyglycerols contain a broad range of polyglycerols chain lengths and the broad range of polyglycerols are present in an amount such that only a few polyglycerol chain lengths dominate the distribution of polyglycerols. For example in a flat distribution one or two polyglycerol chain lengths do not make up 70 or 80% of the total amount of polyglycerols.

For ease of reference these and further aspects of the present invention are now discussed under appropriate section headings. However, the teachings under each section are not necessarily limited to each particular section.

Composition

As previously mentioned, in one aspect the present invention provides a fuel composition comprising:

- (a) a fuel; and
- (b) a polyglycerol ester of a fatty acid;

wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols; triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols; tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols; pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols; hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols; heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols; octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols; nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols; decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

Polyglycerol Ester of a Fatty Acid

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As is understood by one skilled in the art polyglycerol ester of a fatty acid is an emulsifier comprising a polyglycerol 'backbone' onto which fatty acid side chains are attached.

Polyglycerol esters of fatty acids are typically prepared by polymerisation of glycerol to provide one or more polyglycerols to which the fatty acids are then attached. The fatty acids are generally attached by one of two routes. A first route involves the direct attachment of the fatty acid to the polyglycerol. The second route involves inter-esterifying a polyglycerol and a triglyceride thereby transferring fatty acids from the triglyceride to the polyglycerol. The polymerisation of glycerol typically provides a mixture of polyglycerols of different degrees of polymerisation. The mixture of polyglycerols of different degrees of polymerisation is described herein as a polyglycerol composition. It will be understood by one skilled in the art that references to a polyglycerol composition having particular polyglycerol components requires only that those components be present in the amount specified. It will be appreciated by one skilled in the art that because of the nature of polymerisation of glycerol, the polyglycerol composition may contain other polyglycerols having degrees of polymerisation not recited herein. In determining the amounts of polyglycerols in the polyglycerol composition, the total amount of all polyglycerols (irrespective of degree of polymerisation) is determined to provide the total weight of the polyglycerol composition. Materials which are not a

polyglycerol do not form part of the polyglycerol composition and their weight is not considered when determining the total weight of the polyglycerol composition.

References in the present specification to "the combined weight of the polyglycerols" encompass the total combined weight of all polyglycerols, irrespective of their chain length and irrespective of whether the polyglycerol is recited in the listing of polyglycerols.

As discussed here in the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols; triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols; tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols; pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols; hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols; heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols; octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols; nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols; decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

It will be appreciated by one skilled in the art that polyglycerols may be either in the form of a cyclic polyglycerol or an acyclic polyglycerol. Acyclic polyglycerols are straight chain and branched chain polyglycerols, that is acyclic polyglycerols are formed entirely from glycerol groups linked such that no rings are formed. Cyclic polyglycerols contain a ring structure. References in the present specification to a polyglycerol of a particular degree of polymerisation, for example triglycerol referring to a polyglycerol having a degree of polymerisation of 3, include both the polyglycerol in cyclic form and in acyclic form. We have further determined the preferred amounts of cyclic and acyclic polyglycerols for each of diglycerol, triglycerol, tetraglycerol and pentaglycerol. In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 25.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the

triglycerol comprises acyclic triglycerol in an amount of 7.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.5 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect

the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 25.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols;

the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.5 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols,

and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.5 to 13.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect

the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.5 to 13.0 weight% based on the combined weight of the polyglycerols

the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect

the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.5 to 13.0 weight% based on the combined weight of the polyglycerols

the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 1.0 to 8.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

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In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.5 to 13.0 weight% based on the combined weight of the polyglycerols

acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols

heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols

octaglycerol in an amount of 4.0 to 12.0 weight% based on the combined weight of the polyglycerols

nonaglycerol in an amount of 2.0 to 10.0 weight% based on the combined weight of the polyglycerols

decaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

unadecaglycerol in an amount of 0.1 to 7.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols

acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 1.0 to 8.0 weight% based on the combined weight of the polyglycerols; and

acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols

heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols

octaglycerol in an amount of 4.0 to 12.0 weight% based on the combined weight of the polyglycerols

nonaglycerol in an amount of 2.0 to 10.0 weight% based on the combined weight of the polyglycerols

decaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

unadecaglycerol in an amount of 0.1 to 7.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 15.0 to 23.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 13.5 to 20.5 weight% based on the combined weight of the polyglycerols. In

one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises tetraglycerol in an amount of 10.0 to 17.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 8.0 to 14.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 8.0 to 11.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 4.0 to 8.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 1.5 to 6.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 0.5 to 5.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 15.0 to 23.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 13.5 to 20.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises tetraglycerol in an amount of 10.0 to 17.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 8.0 to 14.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
5 comprises hexaglycerol in an amount of 8.0 to 11.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols;

10 the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 4.0 to 8.0 weight% based on the combined
15 weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 1.5 to 6.0 weight% based on the combined weight of the polyglycerols; and

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
20 comprises unadecaglycerol in an amount of 0.5 to 5.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 8.0 to 12.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in
25 an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 9.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 7.5
30 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol in an amount of 5.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.5 to 6.0 weight% based on the combined
35 weight of the polyglycerols.

In one preferred aspect

the diglycerol comprises acyclic diglycerol in an amount of 8.0 to 12.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols;

the triglycerol comprises acyclic triglycerol in an amount of 9.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 5.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

acyclic diglycerol in an amount of 8.0 to 12.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols;

acyclic triglycerol in an amount of 9.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight of the polyglycerols;

acyclic tetraglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols; and

acyclic pentaglycerol in an amount of 5.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols.

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 8.0 to 11.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
5 comprises nonaglycerol in an amount of 4.0 to 8.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 1.5 to 6.0 weight% based on the combined weight of the polyglycerols; and

10 the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 0.5 to 5.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester
15 of a fatty acid comprises diglycerol in an amount of 17.6 to 21.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 15.9 to 18.1 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of
20 a fatty acid comprises tetraglycerol in an amount of 12.5 to 14.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 10.5 to 12.2 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester
25 of a fatty acid comprises hexaglycerol in an amount of 9.3 to 10.1 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 8.6 to 9.9 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of
30 a fatty acid comprises octaglycerol in an amount of 7.3 to 8.9 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 5.5 to 6.4 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of
35 a fatty acid comprises decaglycerol in an amount of 2.9 to 4.5 weight% based on the

combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 1.8 to 3.7 weight% based on the combined weight of the polyglycerols.

5

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 17.6 to 21.0 weight% based on the combined
10 weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 15.9 to 18.1 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
15 comprises tetraglycerol in an amount of 12.5 to 14.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 10.5 to 12.2 weight% based on the combined weight of the polyglycerols;

20 the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 9.3 to 10.1 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 8.6 to 9.9 weight% based on the combined
25 weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 7.3 to 8.9 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
30 comprises nonaglycerol in an amount of 5.5 to 6.4 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 2.9 to 4.5 weight% based on the combined weight of the polyglycerols; and

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 1.8 to 3.7 weight% based on the combined weight of the polyglycerols.

5 In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 9.1 to 11.4 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 8.5 to 9.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 10.0 to 11.8 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in
10 an amount of 5.9 to 6.3 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 8.4 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 4.1 to 4.4 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol
15 in an amount of 6.7 to 7.6 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 3.8 to 4.6 weight% based on the combined weight of the polyglycerols.

In one preferred aspect

20 the diglycerol comprises acyclic diglycerol in an amount of 9.1 to 11.4 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 8.5 to 9.5 weight% based on the combined weight of the polyglycerols;

the triglycerol comprises acyclic triglycerol in an amount of 10.0 to 11.8 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of
25 5.9 to 6.3 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 8.4 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 4.1 to 4.4 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.7 to 7.6
30 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 3.8 to 4.6 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

acyclic diglycerol in an amount of 9.1 to 11.4 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 8.5 to 9.5 weight% based on the combined weight of the polyglycerols;

acyclic triglycerol in an amount of 10.0 to 11.8 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 5.9 to 6.3 weight% based on the combined weight of the polyglycerols;

acyclic tetraglycerol in an amount of 8.4 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 4.1 to 4.4 weight% based on the combined weight of the polyglycerols; and

acyclic pentaglycerol in an amount of 6.7 to 7.6 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 3.8 to 4.6 weight% based on the combined weight of the polyglycerols.

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 9.3 to 10.1 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 8.6 to 9.9 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 7.3 to 8.9 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 5.5 to 6.4 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 2.9 to 4.5 weight% based on the combined weight of the polyglycerols; and

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 1.8 to 3.7 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 18.0 to 32.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an

amount of 16.0 to 24.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises tetraglycerol in an amount of 12.0 to 16.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 8.0 to 12.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 7.0 to 11.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 5.0 to 10.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 3.0 to 9.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 1.5 to 7.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 0.0 to 4.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 0.0 to 4.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

diglycerol in an amount of 18.0 to 32.0 weight% based on the combined weight of the polyglycerols;

triglycerol in an amount of 16.0 to 24.0 weight% based on the combined weight of the polyglycerols;

tetraglycerol in an amount of 12.0 to 16.0 weight% based on the combined weight of the polyglycerols;

pentaglycerol in an amount of 8.0 to 12.0 weight% based on the combined weight of the polyglycerols;

hexaglycerol in an amount of 7.0 to 11.0 weight% based on the combined weight of the polyglycerols;

heptaglycerol in an amount of 5.0 to 10.0 weight% based on the combined weight of the polyglycerols;

octaglycerol in an amount of 3.0 to 9.0 weight% based on the combined weight of the polyglycerols;

5 nonaglycerol in an amount of 1.5 to 7.0 weight% based on the combined weight of the polyglycerols;

decaglycerol in an amount of 0.0 to 4.5 weight% based on the combined weight of the polyglycerols; and

10 unadecaglycerol in an amount of 0.0 to 4.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 9.0 to 24.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols. In
15 one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 9.0 to 20.5 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 3.5 to 6.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 8.0 to 13.5 weight% based on the combined weight of the polyglycerols, and cyclic
20 tetraglycerol in an amount of 2.0 to 4.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.0 to 5.0 weight% based on the combined weight of the polyglycerols.

25

In one preferred aspect in the polyglycerol composition used to form the polyglycerol ester of a fatty acid

the diglycerol comprises acyclic diglycerol in an amount of 9.0 to 24.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of
30 6.5 to 10.0 weight% based on the combined weight of the polyglycerols;

the triglycerol comprises acyclic triglycerol in an amount of 9.0 to 20.5 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 3.5 to 6.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 8.0 to 13.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 2.0 to 4.5 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.0 to 5.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

acyclic diglycerol in an amount of 9.0 to 24.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols;

acyclic triglycerol in an amount of 9.0 to 20.5 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 3.5 to 6.5 weight% based on the combined weight of the polyglycerols;

acyclic tetraglycerol in an amount of 8.0 to 13.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 2.0 to 4.5 weight% based on the combined weight of the polyglycerols;

acyclic pentaglycerol in an amount of 6.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.0 to 5.0 weight% based on the combined weight of the polyglycerols;

hexaglycerol in an amount of 7.0 to 11.0 weight% based on the combined weight of the polyglycerols;

heptaglycerol in an amount of 5.0 to 10.0 weight% based on the combined weight of the polyglycerols;

octaglycerol in an amount of 3.0 to 9.0 weight% based on the combined weight of the polyglycerols;

nonaglycerol in an amount of 1.5 to 7.0 weight% based on the combined weight of the polyglycerols;

decaglycerol in an amount of 0.0 to 4.5 weight% based on the combined weight of the polyglycerols; and

unadecaglycerol in an amount of 0.0 to 4.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 26.0 to 34.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 21.0 to 25.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises tetraglycerol in an amount of 12.0 to 17.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 8.0 to 12.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 6.0 to 10.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 2.5 to 5.5 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 1.0 to 3.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises decaglycerol in an amount of 0.0 to 1.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises undecaglycerol in an amount of 0.0 to 0.5 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises undecaglycerol in an amount of 0.0 to 0.01 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of
diglycerol in an amount of 26.0 to 34.0 weight% based on the combined weight
of the polyglycerols;

triglycerol in an amount of 21.0 to 25.0 weight% based on the combined weight of the polyglycerols;

tetraglycerol in an amount of 12.0 to 17.0 weight% based on the combined weight of the polyglycerols;

5 pentaglycerol in an amount of 8.0 to 12.0 weight% based on the combined weight of the polyglycerols;

hexaglycerol in an amount of 6.0 to 10.0 weight% based on the combined weight of the polyglycerols;

heptaglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight
10 of the polyglycerols;

octaglycerol in an amount of 2.5 to 5.5 weight% based on the combined weight of the polyglycerols;

nonaglycerol in an amount of 1.0 to 3.0 weight% based on the combined weight of the polyglycerols;

15 decaglycerol in an amount of 0.0 to 1.0 weight% based on the combined weight of the polyglycerols; and

unadecaglycerol in an amount of 0.0 to 0.5 weight% based on the combined weight of the polyglycerols.

20 In one preferred aspect the diglycerol comprises acyclic diglycerol in an amount of 20.0 to 26.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 8.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 18.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol
25 in an amount of 2.5 to 5.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the tetraglycerol comprises acyclic tetraglycerol in an amount of 11.0 to 14.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols. In one preferred aspect the pentaglycerol comprises acyclic pentaglycerol
30 in an amount of 6.5 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the triglycerol comprises acyclic triglycerol in an amount of 18.0
35 to 21.0 weight% based on the combined weight of the polyglycerols,

In one preferred aspect in the polyglycerol composition used to form the polyglycerol ester of a fatty acid

the diglycerol comprises acyclic diglycerol in an amount of 20.0 to 26.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 8.0 weight% based on the combined weight of the polyglycerols;

the triglycerol comprises acyclic triglycerol in an amount of 18.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 5.0 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 11.0 to 14.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.5 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

acyclic diglycerol in an amount of 20.0 to 26.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 8.0 weight% based on the combined weight of the polyglycerols;

acyclic triglycerol in an amount of 18.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 5.0 weight% based on the combined weight of the polyglycerols;

acyclic tetraglycerol in an amount of 11.0 to 14.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols;

acyclic pentaglycerol in an amount of 6.5 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols;

hexaglycerol in an amount of 6.0 to 10.0 weight% based on the combined weight of the polyglycerols;

heptaglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight of the polyglycerols;

octaglycerol in an amount of 2.5 to 5.5 weight% based on the combined weight of the polyglycerols;

nonaglycerol in an amount of 1.0 to 3.0 weight% based on the combined weight of the polyglycerols;

5 decaglycerol in an amount of 0.0 to 1.0 weight% based on the combined weight of the polyglycerols; and

 undecaglycerol in an amount of 0.0 to 0.5 weight% based on the combined weight of the polyglycerols.

10 The fatty acid side chains attached to the polyglycerol may be of any suitable length. The polyglycerol ester of a fatty acid may be a polyglycerol ester of a single fatty acid, or polyglycerol ester of a mixture of fatty acids. The fatty chain lengths of the fatty acids of the polyglycerol ester need not be of the same length. Typically the polyglycerol ester of a fatty acid is an ester of a fatty acid of a C12 to C22 fatty acid. Preferably the
15 polyglycerol ester of a fatty acid is an ester of a C16 or C22 fatty acid. Preferably the polyglycerol ester of a fatty acid is an ester of a C16 or C18 fatty acid. Preferably the polyglycerol ester of a fatty acid is an ester of a C18 fatty acid.

 The fatty acid of the polyglycerol ester of a fatty acid may be saturated fatty acid,
20 unsaturated fatty acid or a mixture of saturated fatty acid and unsaturated fatty acid. In one aspect the fatty acid of the polyglycerol ester of a fatty acid is an unsaturated fatty acid. The fatty acid of the polyglycerol ester of a fatty acid may be mono- or di-unsaturated fatty acid. Preferably the fatty acid of the polyglycerol ester of a fatty acid is a mono-unsaturated fatty acid.

25 A highly preferred fatty acid of the polyglycerol ester of a fatty acid is oleic acid ((9Z)-Octadec-9-enoic acid).

 The fatty acids attached to the polyglycerol may be provided from any suitable source.
30 Thus in one aspect, the polyglycerol fatty acid ester is prepared from fatty acids from oils selected from rape seed oil, high oleic rape seed oil, soy oil, high oleic sunflower oil, tall oil and mixtures thereof.

 In one preferred aspect the polyglycerol composition used to form the polyglycerol ester
35 of a fatty acid has a hydroxyl value of from 880 to 1230 mg KOH/g. In one preferred

aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1130 to 1230 mg KOH/g. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 880 to 1060 mg KOH/g. In a further preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 950 to 990 mg KOH/g.

In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 50°C of from 1.4860 to 1.4925. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 50°C of from 1.4895 to 1.4925. In a further preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 50°C of from 1.4900 to 1.4920. In a further preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 50°C of from 1.4900 to 1.4910. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 25°C of from 1.4855 to 1.4935.

In one preferred aspect the polyglycerol ester of a fatty acid has a viscosity of less than 700 mPa s at 20°C, such as less than 600 mPa s at 20°C, such as less than 500 mPa s at 20°C, such as less than 400 mPa s at 20°C, such as less than 350 mPa s at 20°C, such as less than 300 mPa s at 20°C, such as less than 250 mPa s at 20°C, such as less than 200 mPa s at 20°C. We have found that during the preparation of a fuel emulsion in accordance with the present invention a low viscosity, such as that described above, and preferably less than 200 mPa s at 20°C, is an important factor in the preparation of an effective emulsion.

We have found that a means by which the viscosity the polyglycerol ester of a fatty acid may be controlled is by control of the ratio of the polyol to triglyceride source when preparing the present polyglycerol ester of a fatty acid, as well as the fatty acid profile which is described in detail herein. The effect of ratio of the polyol to triglyceride source is shown in Figure 8. Thus in one aspect the polyglycerol ester of a fatty acid is prepared by reacting a polyglycerol and a fatty acid triglyceride in a ratio of polyglycerol to fatty acid triglyceride of from 1:1 to 1:10. Preferably the polyglycerol ester of a fatty acid is prepared by reacting a polyglycerol and a fatty acid triglyceride in a ratio of polyglycerol

to fatty acid triglyceride of from 1:1 to 1:9, such as from 1:1 to 1:8, such as from 1:1 to 1:7, such as from 1:1 to 1:6, such as from 1:1 to 1:5, such as from 1:1 to 1:4, such as from 1:2 to 1:4, such as from 1:2 to 1:3, such as approximately 1:2.8, such as from 1:4 to 1:9, such as from 1:4 to 1:8, such as from 1:4 to 1:7, such as from 1:4 to 1:6, such as
5 from 1:4 to 1:5, such as from 1:5 to 1:7, such as from 1:6 to 1:7, such as approximately 1:6.7.

Fuel Composition

10 When a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein is provided in accordance with the present invention, the polyglycerol ester may be dosed in the water and fuel composition in any suitable amount to provide an emulsion of desired stability. In one aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described
15 herein in an amount of from 0.1 to 2.0 wt.% based on the total fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of from 0.1 to 1.0 wt.% based on the total fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of from 0.1 to 0.5 wt.% based on the total fuel
20 composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of less than 0.5 wt.% based on the total fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of less than 0.3 wt.% based on the total
25 fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of less than 0.25 wt.% based on the total fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of less than 0.2 wt.% based on the total
30 fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of polyglycerols as described herein in an amount of less than 0.15 wt.% based on the total fuel composition. In a further aspect the fuel composition comprises a polyglycerol ester of a fatty acid prepared from a mixture of

polyglycerols as described herein in an amount of less than 0.1 wt.% based on the total fuel composition.

As discussed herein we have identified that by use of the "flat" composition of polyglycerols the emulsifier may be used in lower amounts than required in the prior art. Thus in the preferred aspect the polyglycerol ester of a fatty acid is present in an amount of less than 0.5 wt.%. The improved activity of the composition of polyglycerol esters of the present invention allows for the emulsifier to be dosed at lower amounts than had previously been required in the prior art. This is advantageous both for reasons of cost and also for storage. These materials are dosed in use and therefore must be transported by the user. Minimising the amount of material required to achieve the desired effect is important for end users. Although the present composition allows for use at lower levels than the prior art, the present composition may be dosed at any level, for example it may be dosed at a higher level in a demanding application. It is appreciated by one skilled in the art that depending on the required use and stability time desired the polyglycerol ester of a fatty acid may be dosed at any amount.

Fuel

As discussed herein, the emulsifiers described allow for the preparation of an emulsion of fuel and water. A fuel suitable for preparing into an emulsion but which has yet to be combined with water is hereby encompassed within the present invention. However, in a preferred aspect, the fuel containing the emulsifiers is combined with water and the fuel composition further comprises (c) water. It will be appreciated that in this aspect the fuel composition may be prepared by first dosing the polyglycerol ester of a fatty acid into the fuel, such as marine gasoil (MGO), after which water is dosed into the fuel/emulsifier blend.

The amount of water may be selected based on the requirements of the combustion system. In one aspect the fuel composition further comprises (c) water in an amount of from 10 to 70 wt.% based on the total fuel composition. Preferably the water is present in an amount of from 30 to 60 wt.% based on the total fuel composition. Preferably the water is present in an amount of from 33 to 50 wt.% based on the total fuel composition.

The composition according to the present invention may comprise one or more additives for example, to improve various aspects of the fuel to which the composition is typically added or to improve various aspects of the combustion system performance. Suitable additional additives include detergents, carrier oils, anti-oxidants, corrosion inhibitors, colour stabilisers, metal deactivators, cetane number improvers, other combustion improvers, antifoams, pour point depressants, cold filter plugging point depressants, wax anti-settling additives, dispersants, deodorants, dyes, smoke suppressants, lubricity agents, and other particulate filter regeneration additives.

- 10 The fuel may be any fuel suitable for combustion where reduction of NO_x is desired. In one aspect the fuel is a fuel for spark ignition engines such as a gasoline engine. Preferably the fuel is a fuel for a high compression spontaneous ignition engine. In one aspect the fuel is selected from diesel, heavy fuel oil, marine gasoil (MGO) and kerosene. The diesel may be biodiesel, low sulphur diesel and ultra-low sulphur diesel.
- 15 Preferably the fuel is marine gasoil. The marine gasoil may be any suitable marine gasoil. In one aspect it is a fuel having a (i) a density of 0.85-0.89g/cm³, a cetane Number of approximately 45; and a flash point of greater than 55°C.

Aspects of the invention are defined in the appended claims.

20

The present invention will now be described in further detail in the following examples in which:

Figures 1, 3a, 3b, 7 to 9 and 13 show graphs; and

Figures 2, 3c, 4, 5, 6, 10, 11, 12 and 14 show images.

25

EXAMPLES

Example 1

- 30 Four polyglycerol esters were prepared and tested. Two were broad range polyglycerol (BRPG) esters in accordance with the present invention - one based on soya bean oil and one based on oleic acid. Two were triglycerol esters prepared as a comparison - one based on soya bean oil and one based on oleic acid.

35 **Manufacture of polyglycerol:**

Glycerol: 1250 kg

50% NaOH in water: 9.17 kg

- 5 Glycerol and NaOH solution is added to the reactor. Heated to 240°C while taking care with columns and condensers not to distill off glycerol. The heating to 240°C takes about 3h. Then the pressure is lowered carefully to about 30 mbar to remove reaction water from the polymerisation of glycerol. After about 7-14 hours at 240°C samples are withdrawn from the reactor for measurement of refractive index at 50.0°C, ($n_D^{50,0}$).

10

The refractive index is used to determine the termination of the reaction. The refractive index should be in the interval of 1.4900-1.4920. If the refractive index is not yet in the interval, the reaction is continued for further 1 hour and another sample is withdrawn for measurement. This continues until the refractive index is within the interval. When the
15 polyglycerol is within the stop-interval the temperature is lowered to 120°C.

The glycerol and polyglycerol content of the BRPG samples was determined. The details of this analysis are given below.

Polyglycerol composition	BRPG Batch 1	BRPG Batch 2	BRPG Batch 3 (reanalysis in [])	BRPG Batch 4
%Glycerol	4.81	5.49	4.22 [4.24]	5.15
% CY-Diglycerol	8.68	8.42	9.14 [9.14]	8.13
% Diglycerol	10.04	10.85	8.68 [8.67]	10.58
% CY-Triglycerol	5.94	5.58	6.00 [6.02]	5.70
% Triglycerol	10.57	11.15	9.47 [9.46]	11.00
% CY-Tetraglycerol	4.20	3.90	3.93 [4.24]	4.06
% Tetraglycerol	8.76	9.12	8.00 [8.00]	9.06
% CY-Pentaglycerol	4.13	3.60	4.44 [4.38]	3.59
% Pentaglycerol	6.95	7.20	6.44 [6.53]	6.40
% Hexaglycerol	9.36	8.98	8.89 [9.22]	9.58
% Heptaglycerol	8.71	8.15	8.63 [8.96]	9.44
% Octaglycerol	7.27	7.02	8.52 [7.57]	7.02
% Nonaglycerol	5.58	5.20	6.07 [5.80]	5.36
% Decaglycerol	3.31	3.51	4.20 [4.25]	2.76
% Undecaglycerol	1.69	1.82	3.38 [3.54]	2.17
Normalised from	95.89	97.02	95.59 [95.06]	98.53

20

Specifications of the hydroxyl values and the refractive index for the broad range

polyglycerol of the present invention and the triglycerol used for the esters below are given below:

Broad range polyglycerol

- 5 Hydroxyl value (OHV): 950-990
 Refractive index at 50°C: 1.4900-1.4920

Triglycerol

- Hydroxyl value (OHV): 1090-1190
10 Refractive index (20°C): 1.4930-1.4970

Manufacture of Triglycerol and Polyglycerol esters:

Polyglycerol PGE 2440/198:

- 15 Soyabean oil: 700g
 Polyglycerol: 203.2g
 50% NaOH in water: 3.80g

- 20 The polyglycerol was prepared in accordance with the above process.

All ingredients are charged to a 3-necked flask with mechanical stirring, condenser, temperature control, nitrogen protection is used, vacuum pump is connected to the set-up.

- 25 Temperature is raised to 90°C. Pressure is lowered to about 50 mBar when the mixture reaches 90°C. Temperature is then raised to 230°C and held at that temperature for 30 min. Cooled to about 90°C. Pressure equalised with nitrogen at 90°C. The product is clear.

- 30 Analysis: Acid value: 0.3; Saponification value: 146.2; Hydroxyl value: 219.2.

Polyglycerol PGE 2526/160:

- 35 Oleic acid 90%: 340g

Polyglycerol: 102g
Glycerol: 37g
50% NaOH in water: 1.75g

- 5 The polyglycerol was prepared in accordance with the above process.

All ingredients are charged to a 3-necked flask with mechanical stirring, vigreux column, condenser, temperature control, nitrogen protection is used, vacuum pump is connected to the set-up.

10

Temperature is raised gradually to 235°C. At 208°C reaction water is distilled off. After 80 min. the mixture is clear and the temperature is 235°C. The reaction mixture is reacted for further 1h.

- The pressure is lowered gradually to 75 mBar. Then the mixture reacts for further 1h. A
15 sample is withdrawn for acid value measurement.

When the acid value is below 2 the product is finished and the temperature is lowered to 90°C. Pressure equalised with nitrogen. The product is clear.

- Analysis: Acid value: 0.5; Saponification value: 145.5; Hydroxyl value: 214.9; Alkaline
20 number: 7.4.

Triglycerol PGE 2528/072 (Comparative):

- Soyabean oil: 700g
25 Triglycerol: 215g
50% NaOH in water: 3.80g

The triglycerol was obtained from Solvay.

- 30 All ingredients are charged to a 3-necked flask with mechanical stirring, condenser, temperature control, nitrogen protection is used, vacuum pump is connected to the set-up.

Pressure is lowered to about 50 mBar when the mixture reaches 90°C. Temperature is raised from room temperature to 230°C in 85 min. The reaction mixture is held at 230°C for 2.5h, then cooled to 90°C and pressure equalised with nitrogen. The product is clear.

- 5 Analysis: Acid value: 0.2; Saponification value: 142.6; Iodine value: 95.2; Color 5 1/4", Total: 3.0 yellow: 15 red: 1.5.

Triglycerol PGE 2526/159 (Comparative):

- 10 Oleic acid 90%: 340g
Triglycerol: 108g
Glycerol: 37g
50% NaOH in water: 1.75g

- 15 The triglycerol was obtained from Solvay.

All ingredients are charged to a 3-necked flask with mechanical stirring, vigreux column, condenser, temperature control, nitrogen protection is used, vacuum pump is connected to the set-up.

20

Temperature is raised gradually to 235°C. At 208°C reaction water is observed. After 65 min. the mixture is clear and the temperature is 235°C. The reaction mixture is reacted for further 1h. The pressure is lowered gradually to 75 mBar, then the mixture reacts for further 1h. A sample is withdrawn for acid value measurement. When the acid value is
25 below 2 the product is finished and the temperature is lowered to 90°C. Pressure equalised with nitrogen. The product is clear.

Analysis: Acid value: 0.8; Saponification value: 143.6; Hydroxyl value: 262.8; Alkaline number: 4.6.

30

Four polyglycerol esters based on either soy oil or oleic acid and either triglycerol or broad range polyglycerol (BRPG) esters were tested in water-in-fuel emulsion (WIF-emulsion) with 50% water content at 55°C with focus on water droplet size distribution, stability and emulsion viscosity.

35

The results of the investigations show that BRPG esters provides smaller water droplets and reduced water droplet sedimentation during storage compared to triglycerol esters.

- Four samples were tested with two polyol distributions (triglycerol vs. BRPG) and two fatty acid sources (soy oil vs. pure oleic acid). The main focus of the test was the effect of reduced emulsifier addition on the emulsion stability.

EXPERIMENTAL

- Four emulsifiers were tested in water-in-fuel emulsions, WIF-emulsions, with 50% water content at 55°C. The emulsifiers are listed in table 1. Dosages 0.5%, 0.25% and 0.1% based on the emulsion. The emulsions (200 g) were prepared by slowly adding the water phase to the fuel (MGO) during homogenization with Ultra Turrex at 20500 rpm for 64 s. Both the MGO and the water were heated to 55°C prior to emulsification.
- The following analyses were carried out immediately after preparation of the emulsion:
1. Water droplet size distribution by NMR.
 2. Microscopy by CLSM.
 3. Emulsion stability during 3 hours storage at 55°C by imaging and image analysis.

Polyglycerol Type	Material	Fatty acid composition	Polyglycerol %
BRPG	2440/198	soy oil	23.8*
BRPG	2526/160	Oleate	27.0
Triglycerol	2528/072	soy oil	23.8*
Triglycerol	2526/159	Oleate	28.6

Table 1 * The low polyol percentage is due to the fatty acid source.

The marine gasoil (diesel) used in the testing was Shell Thermo heating oil.

RESULTS

The water droplet size distribution is shown in Table 2. Note the significant increase in water droplet size at low emulsifier concentration.

Emulsifier	Conc % Emulsion	Conc % Diesel	Water % Emulsion	Temp °C	D2.5 µm	D50.0 µm
2440/198 BRPG- soy	0.50	1.00	50	55	0.6	7.7
	0.25	0.50	50	55	3.3	16.6
	0.10	0.20	50	55	4.2	63.0
2526/160 BRPG - oleate	0.50	1.00	50	55	0.5	7.1
	0.25	0.50	50	55	3.7	18.6
	0.10	0.20	50	55	6.7	47.0
2528/072 Triglycerol - soy	0.50	1.00	50	55	0.4	6.6
	0.25	0.50	50	55	2.7	17.8
	0.10	0.20	50	55	2.8	87.8
2526/159 Triglycerol - oleate	0.50	1.00	50	55	0.5	7.4
	0.25	0.50	50	55	1.9	14.9
	0.10	0.20	50	55	4.5	72.7

Table 2 Water droplet size distribution.

The D50.0 values are compared in Figure 1, where the huge increase in droplet size at 0.1% dosage level is clearly seen. The graph also shows that at very stressing conditions (0.1% emulsifier dosage) PGE based on BRPG (broad range polyglycerol) results in smaller water droplets than PGE based on triglycerol. At the same time PGE based on fatty acids from soy oil results in larger droplets than PGE based on pure oleic acid.

The droplet size distribution by CLSM is seen below with a comparison between 0.5% and 0.1% emulsifier dosage. The huge increase in droplet size at low emulsifier dosage is clearly seen on the pictures. Pictures of samples with 0.25% emulsifier addition are shown in Figure 2. Pictures of samples with 0.1%, 0.25% and 0.5% emulsifier addition are shown in Figure 6.

15

In Figure 3a, 3b and 3c are shown the degree of water droplet sedimentation in the emulsions during 3 hours storage at 55°C with 0.5%, 0.25% and 0.1% emulsifier addition. The degree of sedimentation is expressed as the free diesel oil on top of the samples in percentage of the total samples height. The values were generated by image analysis.

20

The difference in the degree of sedimentation between the dosage levels is to be noted. At 0.1% dosage the sedimentation is ten-fold larger than at 0.5% dosage level.

The ester of triglycerol and soy oil performs poorly at low concentration. Hence the performance of this emulsifier is more sensitive to dosage reduction compared to the broad range polyglycerol ester emulsifiers of the present invention.

25

At low concentration the two emulsifiers based on BRPG of the present invention perform better than the emulsifiers based on triglycerol. This is in agreement with the difference in water droplet size illustrated in Figure 1.

5

Pictures of the samples are available in Figures 4 and 5 .

CONCLUSION

- 10 It is clearly documented that polyglycerol esters based on broad range polyglycerols results in smaller water droplet and reduced water droplet sedimentation during storage as compared to polyglycerolesters based on triglycerol. This effect is seen at very low emulsifier addition (0.1%) representing stressing conditions, which most like a real life situation. Furthermore it is concluded that a fatty acids composition with high oleic acid
15 content is superior to a composition with high linoleic acid (soy oil) based on above attributes.

Example 2

- 20 Four further polyglycerol esters were prepared and tested. Each was a broad range polyglycerol (BRPG) esters in accordance with the present invention and each was based on rape seed oil. Two were triglycerol esters and two were hexaglycerol esters.

- The esters in accordance with the present invention were compared against a
25 comparison prepared from triglycerol and soy oil (REF PGE or REF).

EXPERIMENTAL

PGE 2680/060 with polyol 13%:

30

Rapeseed oil:	920g
Broad Range Hexaglycerol (BRHG):	138g
50% NaOH in water:	1.92g

The hexaglycerol was prepared by polymerisation in the same manner as described in Example 1.

All ingredients are charged to a 3-necked flask with mechanical stirring, condenser, temperature control, nitrogen protection is used, vacuum pump is connected to the set-up.

Pressure is lowered to 50 - 100 mBar when the mixture reaches 235°C and is clear. Temperature is raised from room temperature to 235°C in 50 min. The reaction mixture is held at 235°C for 2.5h, then cooled to 100°C and pressure equalised with nitrogen. The product is clear.

Analysis: Acid value: 0.2; Saponification value: 161.8; Hydroxyl value: 125; Alkaline number: 3.9

PGE 2680/065 with polyol 10%:

Rapeseed oil:	960g
Broad Range Hexaglycerol (BRHG):	106.6g
50% NaOH in water:	2.4g

The hexaglycerol was prepared by polymerisation in the same manner as described in Example 1.

All ingredients are charged to a 3-necked flask with mechanical stirring, condenser, temperature control, nitrogen protection is used, vacuum pump is connected to the set-up.

Pressure is lowered to 50 - 100 mBar when the mixture reaches 235°C and is clear. Temperature is raised from room temperature to 235°C in 50 min. The reaction mixture is held at 235°C for 2.5h, then cooled to 100°C and pressure equalised with nitrogen. The product is clear.

Analysis: Acid value: 0.2; Saponification value: 168.6; Hydroxyl value: 100.2; Alkaline number: 4.1

PGE 2680/062 with polyol 23%:

5	Rapeseed oil:	450g
	Broad Range Triglycerol (BRTG):	135g
	50% NaOH in water:	0.82g

The triglycerol was prepared by polymerisation in the same manner as described in
10 Example 1 except the refractive index was at 25°C was changed from 1.4855 to 1.4935.

All ingredients are charged to a 3-necked flask with mechanical stirring, condenser,
temperature control, nitrogen protection is used, vacuum pump is connected to the set-
up.

15 Pressure is lowered to 50 - 100 mBar when the mixture reaches 235°C and is clear.
Temperature is raised from room temperature to 235°C in 50 min. The reaction mixture is
held at 235°C for 2.5h, then cooled to 100°C and pressure equalised with nitrogen. The
product is clear.

20 Analysis: Acid value: 0.1; Saponification value: 144.9; Hydroxyl value: 241.4; Alkaline
number: 5.0

PGE 2680/073 with polyol 13%:

25	Rapeseed oil:	500g
	Broad Range Triglycerol (BRTG):	75g
	50% NaOH in water:	0.8g

30 The triglycerol was prepared by polymerisation in the same manner as described in
Example 1 except the refractive index was at 25°C was changed from 1.4855 to 1.4935.

All ingredients are charged to a 3-necked flask with mechanical stirring, condenser,
35 temperature control, nitrogen protection is used, vacuum pump is connected to the set-
up.

Pressure is lowered to 50 - 100 mBar when the mixture reaches 235°C and is clear. Temperature is raised from room temperature to 235°C in 50 min. The reaction mixture is held at 235°C for 2.5h, then cooled to 100°C and pressure equalised with nitrogen. The product is clear.

Analysis: Acid value: 0.2; Saponification value: 163.9; Hydroxyl value: 147.5; Alcaline number: 3.7

10 Polyol Distribution

The polyol distribution of the polyol used in the preparation of each of 2680/062 and 2680/073 was analysed. The analyses was performed twice and an average taken. The results of this analysis are given in Table 3 below.

	Analysis 1	Analysis 2	Average of 2 Analyses	Polyol % based on total Polyols
%Glycerol	11.08	10.9998	11.03	
% CY-Diglycerol	6.42	6.37	6.4	7.19%
% Diglycerol	21.56	21.51	21.54	24.20%
% CY-Triglycerol	2.96	3	2.98	3.35%
% Triglycerol	17.74	17.89	17.8182	20.02%
% CY-Tetraglycerol	1.98	2.06	2.02	2.27%
% Tetraglycerol	11.52	11.79	11.6566	13.10%
% CY-Pentaglycerol	2.78	2.7	2.74	3.08%
% Pentaglycerol	6.8	6.93	6.87	7.72%
% Hexaglycerol	6.53	6.67	6.6	7.42%
% Heptaglycerol	4.84	4.89	4.87	5.47%
% Octaglycerol	3.15	3	3.07	3.45%
% Nonaglycerol	1.9	1.62	1.76	1.98%
% Decaglycerol	0.74	0.58	0.66	0.74%
%Undecaglycerol	0	0	0	0.00%

Table 3 - Polyol duplicate analysis

The polyglycerol esters synthesized are summarised in Table 4. Three types of polyglycerol were included in series, they were two triglycerols and one hexaglycerol The fatty acid source was either soy oil or rape seed oil.

Sample	Polyol type	Wt. % Polyol	Oil Type
REF PGE	Tri	23.8	Soy

J 2680/053	BRHG	19.0	Soy
J 2680/054	BRHG	16.0	rape seed
J 2680/060	BRHG	13.0	rape seed
J 2680/062	BRTG	23.1	rape seed
J 2680/065	BRHG	10.0	rape seed
J 2680/073	BRTG	13.0	rape seed

Table 4. BRHG / BRTG: Broad range Hexa/Tri-Glycerol

The difference in polyol composition is shown below

- 5 The polyol distribution of samples REF PGE, the BRTG used in the preparation of 2680/073 and the BRHG used in the preparation of 2680/060 are shown in Table 5.

	REF PGE	BRTG	BRHG
%Glycerol	0.1	11	5.2
% CY-Diglycerol	0	6.4	9
% Diglycerol	27	21.5	9.7
% CY-Triglycerol	2.5	3	5.7
% Triglycerol	44.2	17.8	10.3
% CY-Tetraglycerol	4.1	2	4
% Tetraglycerol	12.4	11.7	8.5
% CY-Pentaglycerol	1.6	2.7	4.1
% Pentaglycerol	4.2	6.9	6.8
% Hexaglycerol	2.5	6.6	9.2
% Heptaglycerol	1.2	4.9	8.5
% Octaglycerol	0	3.1	7
% Nonaglycerol	0	1.8	5.4
% Decaglycerol	0	0.7	3.6
%Undecaglycerol	0	0	3.1

Table 5. polyol distribution of samples

- 10 The viscosity of each emulsifier was measured on a Physica Rheometer using the following setup:

Temp: 60°C to -10°C (1 °C/min), Shear rate : 23 1/s, Measuring system: DG26.7 7-SN711; d=0mm

- 15 Selected emulsifiers (REF PGE, J2680/060, J2680/065, J2680/073) were further tested in WIF-emulsions with 50% water content at 55°C at 0.1% and 0.2% dosage. Diesel quality: MGO.

WIF-samples were prepared as described in Example 1.

RESULTS

The droplet size distribution is shown in Table 6 and graphically in Figure 9 for D50.0 values. Samples 2680/065 and 2680/073 were not stable enough to allow NMR measurement.

Sample	Dosage %	D2.5 μm	D50.0 μm	comments
REF PGE	0.1	1.6	81.0	
J 2680/060	0.1	5.3	100.0	
J 2680/065	0.1	-	-	Too fast sedimentation
J 2680/073	0.1	-	-	Water phase separation
REF PGE	0.2	4.2	19.3	
J 2680/060	0.2	7.9	32.6	
J 2680/065	0.2	3.7	100.0	
J 2680/073	0.2	-	-	Water phase separation

Table 6 water droplet size distribution

- 10 The CLSM pictures of the emulsion are shown in Figure 10. The images were recorded immediately after emulsification. Samples 2680/065 and 2680/073 both provides much bigger water droplets at both emulsifier dosage levels as compared to the reference (REF PGE) and 2680/060.
- 15 The CLSM images of Figure 11 show a dramatic increase in the water droplet size at low emulsifier dosage for samples 2680/065 and 2680/073 as a sign of reduced functionality. Also at 0.2% dosage level, the droplets are clearly larger than for samples REF PGE and 2680/060.
- 20 Sedimentation and water phase separation after 1h, 2, and 3h storage at 55°C for sample 2680/073 are shown in Figure 12. Such pronounced water separation is unusual with WIF-emulsions. Sedimentation at rest however is not a problem as a homogeneous emulsion will be reformed during flow
- 25 Images of the emulsions are shown in Figure 14.

The degree of water droplet sedimentation in the emulsions expressed as the amount of free oil on top formed during 3 hours of storage at 55°C is shown in Figure 13.

All publications mentioned in the above specification are herein incorporated by
5 reference. Various modifications and variations of the described methods and system of
the invention will be apparent to those skilled in the art without departing from the scope
and spirit of the invention. Although the invention has been described in connection with
specific preferred embodiments, it should be understood that the invention as claimed
should not be unduly limited to such specific embodiments. Indeed, various modifications
10 of the described modes for carrying out the invention which are obvious to those skilled
in chemistry or related fields are intended to be within the scope of the following claims

CLAIMS

1. A fuel composition comprising:
(a) a fuel; and
5 (b) a polyglycerol ester of a fatty acid;
wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of
diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of
the polyglycerols;
10 triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of
the polyglycerols;
tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight
of the polyglycerols;
pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined
15 weight of the polyglycerols;
hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight
of the polyglycerols;
heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined
weight of the polyglycerols;
20 octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight
of the polyglycerols;
nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight
of the polyglycerols;
decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight
25 of the polyglycerols; and
unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined
weight of the polyglycerols.
2. A fuel composition according to claim 1 herein the polyglycerol composition used
30 to form the polyglycerol ester of a fatty acid comprises a mixture of
diglycerol in an amount of 11.0 to 28.0 weight% based on the combined weight of
the polyglycerols;
triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of
the polyglycerols;

tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols;

pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols;

5 hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols;

heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols;

10 octaglycerol in an amount of 4.0 to 12.0 weight% based on the combined weight of the polyglycerols;

nonaglycerol in an amount of 2.0 to 10.0 weight% based on the combined weight of the polyglycerols;

decaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

15 unadecaglycerol in an amount of 0.1 to 7.0 weight% based on the combined weight of the polyglycerols.

3. A fuel composition according to claim 1 wherein

20 the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 25.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols

the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

25 the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.5 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols; and

30 the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

4. A fuel composition according to claim 2 wherein

35 the diglycerol comprises acyclic diglycerol in an amount of 6.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols

the triglycerol comprises acyclic triglycerol in an amount of 7.0 to 15.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 9.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in an amount of 1.0 to 8.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 3.0 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 0.5 to 8.0 weight% based on the combined weight of the polyglycerols.

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5. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 15.0 to 23.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 13.5 to 20.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises tetraglycerol in an amount of 10.0 to 17.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises pentaglycerol in an amount of 8.0 to 14.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 8.0 to 11.5 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols;

30

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 4.0 to 8.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
5 comprises decaglycerol in an amount of 1.5 to 6.0 weight% based on the combined weight of the polyglycerols; and

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 0.5 to 5.0 weight% based on the combined weight of the polyglycerols.

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6. A fuel composition according to claim 5 wherein

the diglycerol comprises acyclic diglycerol in an amount of 8.0 to 12.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols;

15 the triglycerol comprises acyclic triglycerol in an amount of 9.0 to 13.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 4.5 to 7.5 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 7.5 to 11.0 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in
20 an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 5.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.5 to 6.0 weight% based on the combined weight of the polyglycerols.

25 7. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises diglycerol in an amount of 17.6 to 21.0 weight% based on the combined
30 weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises triglycerol in an amount of 15.9 to 18.1 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises tetraglycerol in an amount of 12.5 to 14.0 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
5 comprises pentaglycerol in an amount of 10.5 to 12.2 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises hexaglycerol in an amount of 9.3 to 10.1 weight% based on the combined weight of the polyglycerols;

10 the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises heptaglycerol in an amount of 8.6 to 9.9 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises octaglycerol in an amount of 7.3 to 8.9 weight% based on the combined
15 weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises nonaglycerol in an amount of 5.5 to 6.4 weight% based on the combined weight of the polyglycerols;

the polyglycerol composition used to form the polyglycerol ester of a fatty acid
20 comprises decaglycerol in an amount of 2.9 to 4.5 weight% based on the combined weight of the polyglycerols; and

the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises unadecaglycerol in an amount of 1.8 to 3.7 weight% based on the combined weight of the polyglycerols.

25

8. A fuel composition according to claim 7 wherein

the diglycerol comprises acyclic diglycerol in an amount of 9.1 to 11.4 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 8.5 to 9.5 weight% based on the combined weight of the polyglycerols;

30 the triglycerol comprises acyclic triglycerol in an amount of 10.0 to 11.8 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 5.9 to 6.3 weight% based on the combined weight of the polyglycerols;

the tetraglycerol comprises acyclic tetraglycerol in an amount of 8.4 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in
35 an amount of 4.1 to 4.4 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.7 to 7.6 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 3.8 to 4.6 weight% based on the combined weight of the polyglycerols.

- 5 9. A fuel composition according to claim 1 wherein in the polyglycerol composition used to form the polyglycerol ester of a fatty acid

the diglycerol comprises acyclic diglycerol in an amount of 9.0 to 24.5 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 10.0 weight% based on the combined weight of the polyglycerols;

- 10 the triglycerol comprises acyclic triglycerol in an amount of 9.0 to 20.5 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 3.5 to 6.5 weight% based on the combined weight of the polyglycerols;

- the tetraglycerol comprises acyclic tetraglycerol in an amount of 8.0 to 13.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in
15 an amount of 2.0 to 4.5 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.0 to 9.0 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 2.0 to 5.0 weight% based on the combined weight of the polyglycerols.

- 20 10. A fuel composition according to claim 7 wherein in the polyglycerol composition used to form the polyglycerol ester of a fatty acid

the diglycerol comprises acyclic diglycerol in an amount of 20.0 to 26.0 weight% based on the combined weight of the polyglycerols, and cyclic diglycerol in an amount of 6.5 to 8.0 weight% based on the combined weight of the polyglycerols;

- 25 the triglycerol comprises acyclic triglycerol in an amount of 18.0 to 21.0 weight% based on the combined weight of the polyglycerols, and cyclic triglycerol in an amount of 2.5 to 5.0 weight% based on the combined weight of the polyglycerols;

- the tetraglycerol comprises acyclic tetraglycerol in an amount of 11.0 to 14.5 weight% based on the combined weight of the polyglycerols, and cyclic tetraglycerol in
30 an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols; and

the pentaglycerol comprises acyclic pentaglycerol in an amount of 6.5 to 9.5 weight% based on the combined weight of the polyglycerols, and cyclic pentaglycerol in an amount of 1.5 to 4.0 weight% based on the combined weight of the polyglycerols.

11. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 880 to 1230 mg KOH/g.
- 5 12. A fuel composition according to claims 11 wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1130 to 1230 mg KOH/g.
13. A fuel composition according to claim 11 wherein the polyglycerol composition
10 used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 880 to 1060 mg KOH/g.
14. A fuel composition according to claim 11 wherein the polyglycerol composition
15 used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 950 to 990.
15. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 25°C of from 1.4855 to 1.4935.
20
16. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 50°C of from 1.4895 to 1.4925.
- 25 17. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 50°C of from 1.4900 to 1.4920.
18. A fuel composition according to any one of the preceding claims wherein the
30 polyglycerol ester of a fatty acid has a viscosity of less than 700 mPa s at 20°C
19. A fuel composition according to any one of the preceding claims wherein the polyglycerol ester of a fatty acid has a viscosity of less than 200 mPa s at 20°C

20. A fuel composition according to any one of the preceding claims wherein the polyglycerol ester of a fatty acid is prepared by reacting a polyglycerol and a fatty acid triglyceride in a ratio of polyglycerol to fatty acid triglyceride of from 1:1 to 1:8.
- 5 21. A fuel composition according to any one of the preceding claims wherein the (b) a polyglycerol ester of a fatty acid is present in an amount of no greater than 0.5wt% based on the total fuel composition.
22. A fuel composition according to any one of the preceding claims wherein the (b) a
10 polyglycerol ester of a fatty acid is present in an amount of no greater than 0.25wt% based on the total fuel composition.
23. A fuel composition according to any one of the preceding claims wherein the (b) a
15 polyglycerol ester of a fatty acid is present in an amount of no greater than 0.2wt% based on the total fuel composition.
24. A fuel composition according to any one of the preceding claims wherein the (b) a
20 polyglycerol ester of a fatty acid is present in an amount of no greater than 0.1wt% based on the total fuel composition.
25. A fuel composition according to any one of the preceding claims wherein the fuel is selected from diesel, heavy fuel oil, marine gasoil and kerosene.
- 26 A fuel composition according to claim 25 wherein the fuel is marine gasoil.
25
27. A fuel composition according to any one of the preceding claims, wherein the fuel composition further comprises (c) water.
28. A fuel composition according to claim 27, wherein the fuel composition further
30 comprises (c) water in an amount of from 10 to 70 wt.% based on the total fuel composition.
29. A fuel composition according to claim 27, wherein the fuel composition further
35 comprises (c) water in an amount of from 30 to 60 wt.% based on the total fuel composition.

30. A fuel composition according to claim 27, wherein the fuel composition further comprises (c) water in an amount of from 33 to 50 wt.% based on the total fuel composition.

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31. A method for improving the stability of a fuel composition containing (a) fuel and (c) water, the method comprising mixing with the fuel and water, (b) a polyglycerol ester of a fatty acid;

wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid
10 comprises a mixture of

diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols;

triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols;

15 tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols;

pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols;

20 hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols;

heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols;

octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols;

25 nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols;

decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and

30 unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

32. A method according to claim 31, characterised by the features of any one of claims 2 to 30.

33. Use of a polyglycerol ester of a fatty acid for improving the stability of a fuel composition containing fuel and water;

wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

5 diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols;

triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols;

10 tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols;

pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols;

hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols;

15 heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols;

octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols;

20 nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols;

decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and

unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

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34. A kit for preparing a fuel composition as defined in any one of claims 1 to 30, the kit comprising

a polyglycerol ester of a fatty acid; wherein the polyglycerol composition used to form the polyglycerol ester of a fatty acid comprises a mixture of

30 diglycerol in an amount of 11.0 to 34.0 weight% based on the combined weight of the polyglycerols;

triglycerol in an amount of 9.5 to 24.5 weight% based on the combined weight of the polyglycerols;

35 tetraglycerol in an amount of 6.0 to 21.0 weight% based on the combined weight of the polyglycerols;

pentaglycerol in an amount of 3.5 to 19.0 weight% based on the combined weight of the polyglycerols;

hexaglycerol in an amount of 6.0 to 13.5 weight% based on the combined weight of the polyglycerols;

5 heptaglycerol in an amount of 5.0 to 13.0 weight% based on the combined weight of the polyglycerols;

octaglycerol in an amount of 3.0 to 12.0 weight% based on the combined weight of the polyglycerols;

10 nonaglycerol in an amount of 1.5 to 10.0 weight% based on the combined weight of the polyglycerols;

decaglycerol in an amount of 0.0 to 8.0 weight% based on the combined weight of the polyglycerols; and

unadecaglycerol in an amount of 0.0 to 7.0 weight% based on the combined weight of the polyglycerols.

15 together with instructions for use to prepare the fuel composition.

35. A fuel composition substantially as hereinbefore described with reference to any one of the Examples.

20 36. A method substantially as hereinbefore described with reference to any one of the Examples.

37. A use substantially as hereinbefore described with reference to any one of the Examples.

25

38. A kit substantially as hereinbefore described with reference to any one of the Examples.