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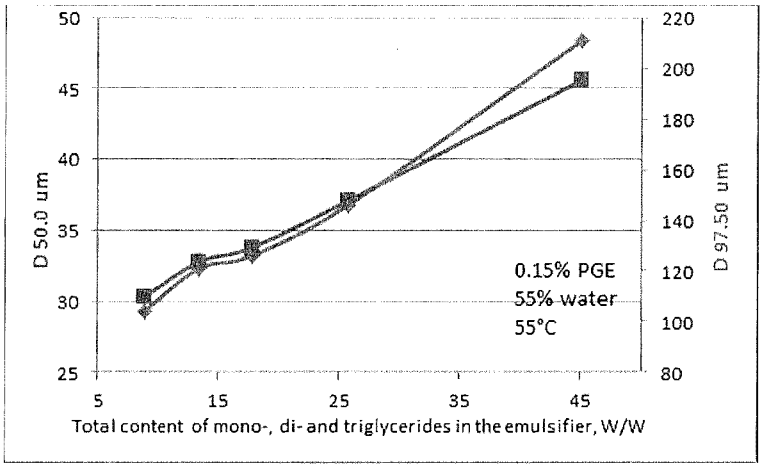

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Figure 1

(57) Abstract: The present invention provides a fuel composition comprising: (a) a fuel; and (b) one or more polyglycerol esters of a fatty acid; wherein the fuel composition contains monoglycerides, diglycerides and triglycerides in a combined amount of less than wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

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FUEL COMPOSITIONS COMPRISING POLYGLYCEROL ESTERS OF A FATTY ACID

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

As discussed in US 7,491,247 environmental considerations and government regulations have increased the need to reduce nitrogen oxide (NOx) 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 (NOx). 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.

Various methods for reducing NOx 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 NOx 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.

It has been shown that introducing water into the combustion zone can lower the flame temperature and thus lower NOx production. The introduction of water into the combustion zone is also known to improve fuel efficiency. 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.

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 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.

WO2013/001064 teaches that many of the problems of the prior art may be overcome by selection of a polyglycerol ester formed from a polyglycerol having a particular profile of polyglycerol components. A 'broad range polyglycerol' is utilised.

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.

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) one or more polyglycerol esters of a fatty acid;
wherein the fuel composition contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

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 (b) a polyglycerol ester of a fatty acid with the fuel and water to form a fuel composition,
wherein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

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 ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

In one aspect the present invention provides a kit for preparing a fuel composition comprising

(a) a fuel; and

(b) one or more polyglycerol esters of a fatty acid;

wherein the fuel composition contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition,

wherein the kit comprises

a polyglycerol ester of a fatty acid; wherein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides.

We have found that the prior art polyglycerol ester systems contain a high (more than 10 wt.%) of glycerides, namely monoglycerides, diglycerides and triglycerides. We have further surprisingly found that by reducing the level of glycerides to less than 10 wt.% then more stable emulsions of fuel and water may be prepared. Thus by providing more stable emulsions then lower and therefore commercially more attractive viable amounts 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. It will also be understood that a more stable emulsion may provide for the same dosage of emulsifier a emulsified composition which is stable over a greater period, which allows for a more 'strained' system i.e. one with a higher water content, or a combination of both.

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) one or more polyglycerol esters of a fatty acid;

wherein the fuel composition contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

Glycerides

As discussed herein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides. As will be understood by one skilled in the art, if the amount of polyglycerol ester of a fatty acid, amount of monoglycerides, amount of diglycerides and amount of triglycerides are added together, the combined amount of monoglycerides, diglycerides and triglycerides is less than 10% by weight.

In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 9 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 8 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 7 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 6 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are

present in a combined amount of less than 5 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 4 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 3 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 2 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 1 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 0.5 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 0.1 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides. In one aspect the monoglycerides, diglycerides and triglycerides are present in a combined amount of less than 0.01 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides.

Polyglycerol Ester of a Fatty Acid

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.

The polyglycerol esters of fatty acids are formed from any suitable single polyglycerol or any suitable mixture of polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least diglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least triglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least tetraglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least pentaglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least hexaglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least heptaglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least octaglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least nonaglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least decaglycerol. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises at least unadecaglycerol.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises diglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises tetraglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises pentaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises heptaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises octaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises nonaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises decaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises unadecaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 2 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 5 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 7 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the

polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 9 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 11 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 13 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 15 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 16 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 17 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 18 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 19 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of at least 20 wt.% based on the combined weight of the polyglycerols.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of no greater than 90 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of no greater than 80 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of no greater than 70 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of no greater than 60 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of no greater than 55 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol

esters of a fatty acid comprises triglycerol in an amount of no greater than 50 wt.% based on the combined weight of the polyglycerols.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 1 to 90 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 2 to 80 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 5 to 70 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 7 to 60 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 9 to 55 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 10 to 55 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 10 to 50 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 12 to 50 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 14 to 50 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 16 to 50 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 18 to 20 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 20 to 50 wt. % based on the combined weight of the polyglycerols.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 1 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the

polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 2 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 3 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 4 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 5 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of at least 6 wt.% based on the combined weight of the polyglycerols.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 20 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 19 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 18 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 17 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 16 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 15 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 14 wt.% based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of no greater than 13 wt.% based on the combined weight of the polyglycerols.

In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 1 to 20 wt. % based on the combined

weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 2 to 19 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 3 to 18 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 4 to 17 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 5 to 16 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 6 to 15 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 6 to 14 wt. % based on the combined weight of the polyglycerols. In one aspect the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises hexaglycerol in an amount of from 6 to 13 wt. % based on the combined weight of the polyglycerols.

In one aspect the polyglycerol esters of a fatty acid may be as described in WO2013/001064 e.g. a 'broad range polyglycerol' may be utilised. In one aspect the polyglycerol composition used to form the polyglycerol esters 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.

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 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, 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.

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

In one aspect the fatty acid composition used to form the polyglycerol ester of a fatty acid comprises oleic acid in an amount of least 50 wt. % based on the combined weight of the fatty acids. In one aspect the fatty acid composition used to form the polyglycerol ester of a fatty acid comprises oleic acid in an amount of least 60 wt. % based on the combined weight of the fatty acids. In one aspect the fatty acid composition used to form the polyglycerol ester of a fatty acid comprises oleic acid in an amount of least 70 wt. % based on the combined weight of the fatty acids. In one aspect the fatty acid composition used to form the polyglycerol ester of a fatty acid comprises oleic acid in an amount of

least 80 wt. % based on the combined weight of the fatty acids. In one aspect the fatty acid composition used to form the polyglycerol ester of a fatty acid comprises oleic acid in an amount of least 90 wt. % based on the combined weight of the fatty acids.

The fatty acids attached to the polyglycerol may be provided from any suitable source. 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 aspect 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. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 900 to 1200 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 930 to 1200 mg KOH/g. In a further aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 960 to 1170 mg KOH/g.

In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1150 to 1190 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1155 to 1185 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1160 to 1180 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1160 to 1175 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1160 to 1170 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 1165 to 1170 mg KOH/g.

In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 950 to 970 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 955 to 970 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 950 to 965 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty

acid has a hydroxyl value of from 955 to 965 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 960 to 970 mg KOH/g. In one aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a hydroxyl value of from 960 to 965 mg KOH/g.

It will be understood by one skilled in the art that polyglycerol may be described by their degree of polymerisation. Those skilled in the art may also name a polyglycerol mixture as if it were a specific polyglycerol, such as a triglycerol, when that polyglycerol mixture has a hydroxyl number equivalent to the hydroxyl number of the specific polyglycerol, such as a triglycerol. The hydroxyl number ranges of glycerol and the specific polyglycerols diglycerol to undecaglycerol are given below.

Glycerol: 1850-1590mg KOH/g

Diglycerol: 1589-1260mg KOH/g

Triglycerol: 1259-1120mg KOH/g

Tetraglycerol: 1119-1041mg KOH/g

Pentaglycerol: 1040-991mg KOH/g

Hexaglycerol: 990-956mg KOH/g

Heptaglycerol: 955-930mg KOH/g

Octaglycerol: 929-910mg KOH/g

Nonaglycerol: 909-894mg KOH/g

Decaglycerol: 893-881mg KOH/g

Undecaglycerol: 880-871mg KOH/g

Therefore a mixture of polyglycerols having a hydroxyl number of 1200mg KOH/g may be referred to as a triglycerol.

In one aspect the polyglycerol is diglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 1589 to 1260mg KOH/g. In one aspect the polyglycerol is triglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 1259 to 1120mg KOH/g. In one aspect the polyglycerol is tetraglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 1119 to 1041mg KOH/g. In one aspect the polyglycerol is pentaglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 1040 to 991mg KOH/g. In one aspect the polyglycerol is hexaglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 990 to 956mg KOH/g. In one aspect the polyglycerol is heptaglycerol. In one aspect the polyglycerol is a

polyglycerol having a hydroxyl number of from 955 to 930mg KOH/g. In one aspect the polyglycerol is octaglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 929 to 910mg KOH/g. In one aspect the polyglycerol is nonaglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 909 to 894mg KOH/g. In one aspect the polyglycerol is decaglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 893 to 881mg KOH/g. In one aspect the polyglycerol is undecaglycerol. In one aspect the polyglycerol is a polyglycerol having a hydroxyl number of from 880 to 871mg KOH/g.

In one preferred aspect all references to polyglycerols are references to polyglycerols having the stated degree of polymerisation e.g. all references to triglycerol are references to polyglycerol with a degree of polymerisation of 3.

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 1.486 to 1.492. 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 1.488 to 1.492. 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 1.487 to 1.491. 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 1.488 to 1.490. 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 20°C of from 1.490 to 1.500. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 20°C of from 1.491 to 1.499. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 20°C of from 1.492 to 1.498. In one preferred aspect the polyglycerol composition used to form the polyglycerol ester of a fatty acid has a refractive index at 20°C of from 1.493 to 1.497.

In one aspect the polyglycerol ester of a fatty acid is prepared by reacting a polyglycerol and fatty acids in a ratio of polyglycerol to fatty acids of from 1:1 to 1:10. In one aspect

the polyglycerol ester of a fatty acid is prepared by reacting a polyglycerol and fatty acids in a ratio of polyglycerol to fatty acids 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. In one aspect the polyglycerol ester of a fatty acid is prepared by reacting a polyglycerol and fatty acids in a ratio of polyglycerol to fatty acids of 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 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

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 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 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 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 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 composition of the present invention containing mono-, di- and triglycerides in a combined amount of less than 10 wt.%, 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. Marine gasoil may also be known as marine diesel oil

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 15 to 60 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.

The fuel may be any fuel suitable for combustion where reduction of NOx 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. 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/cm^3, a cetane Number of approximately 45; and a flash point of greater than 55°C.

Method

As discussed herein, 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 (b) a polyglycerol ester of a fatty acid with the fuel and water to form a fuel composition,

wherein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

As will be understood by one skilled in the art, the fuel, the water and the polyglycerol ester of a fatty acid may be added in any suitable order. In one aspect, the polyglycerol ester of a fatty acid is combined with the fuel and this in turn in combined with the water. In one aspect, the polyglycerol ester of a fatty acid is combined with the water and this in turn in combined with the fuel. In one aspect, the water is combined with the fuel and this in turn in combined with the polyglycerol ester of a fatty acid. In one aspect, the water, the fuel and the polyglycerol ester of a fatty acid are combined in a single step.

Aspects of the invention are defined in the appended claims.

The present invention will now be described in further detail in the following examples in which Figures 1 and 2 show graphs.

EXAMPLES

Polyglycerol Ester (PGE) Compositions

Hexaglycerol (PGE 20140620-009)

An ester of hexaglycerol was prepared based on 32.5 wt.% hexaglycerol and 67.5 wt.% of fatty acids. The profile of the fatty acids was

Fatty acid	wt.%
C16	4.3
C18	4.8
C18:1	77.3
C18:2	12.1
C18:3	0.1

The hydroxyl value for the Hexaglycerol (Hexa) was 962.5 and the refractive index measured at 50°C (N0) was 1.4890. The hexaglycerol had the following polyglycerol profile (wherein Cy means cyclic).

Glycerol	5.40 wt.%
Cy-Diglycerol	9.06 wt.%
Diglycerol	10.15 wt.%

Cy-Triglycerol	5.95 wt.%
Triglycerol	10.67 wt.%
Cy-Tetraglycerol	4.04 wt.%
Tetraglycerol	8.90 wt.%
Cy-Pentaglycerol	4.10 wt.%
Pentaglycerol	7.10 wt.%
Hexaglycerol	9.60 wt.%
Heptaglycerol	9.07 wt.%
Octaglycerol	7.74 wt.%
Nonaglycerol	5.31 wt.%
Decaglycerol	2.92 wt.%
Undecaglycerol	0.00 wt.%

Triglycerol (PGE20141208-074)

An ester of triglycerol was prepared based on 33.5wt.% triglycerol and 66.5 wt.% of fatty acids. The profile of the fatty acids was similar profile to the profile of the fatty acids used in the preparation of PGE 20140620-009.

The hydroxyl value for the Triglycerol (Tri) was 1168 and the refractive index measured at 20°C (N20) was 1.4930 to 1.4970. The triglycerol had the following polyglycerol profile.

Polyol Composition	Wt. %
Glycerol	0.1
Diglycerol	27.0
CY-diglycerol	0
Triglycerol	44.2
CY-triglycerol	2.5
Tetraglycerol	12.5
CY-tetraglycerol	4.2
Pentaglycerol	4.2
CY-Pentaglycerol	1.6
Hexaglycerol	2.5
Heptaglycerol	1.2
Octaglycerol	0
Nonaglycerol	0
Decaglycerol	0

Mono-diglycerides

Variation in the mono, di and triglycerides content in the PGE was achieved by adding amount of a mono-diglyceride mixture (ELN 20141106-016) to the PGE. ELN 20141106-016 had a fatty acid profile similar to the profile of the fatty acids used in the preparation of PGE 20140620-009 and contained 39.6 wt.% monoglyceride, 47.5 wt.% diglyceride and 12.6 wt.% triglyceride .

Process

200 g of emulsion were prepared by slowly adding the water phase to marine gas oil during intensive homogenisation with an Ultra Turrex at 20000 rpm for 60 s. The emulsifier was dissolved in the marine gasoil prior to emulsification (except trial 10 where the emulsifier was added to the water phase). Both the gasoil and the water phase were heated to the 55°C in advance.

Water content: 15%, 33% and 50%

Emulsifier dosage: 0.1% and 0.15% (based on the total emulsion)

Water droplet size distribution was measured by NMR immediately after preparation of the emulsion.

Results

The below table shows the test program and the content of mono, di and triglycerides in the PGE as well as the water droplet size distribution for the emulsions. The graphs show that increasing total content of mono, di and triglycerides in the PGE results in increased water droplet size.

No	Emul	PGE-Polyol	Dosage %	Water %	Temp °C	Mono %	Di %	Tri %	Sum	D50.0	D97.5
1	PGE 20140620-009	Hexa	0.15	50	55	2.3	5.2	1.3	8.8	30.3	104
2	PGE 20140620-009 + monodi	Hexa	0.1425 + 0.0075	50	55	4.2	7.3	1.9	13.4	32.8	121
3	PGE 20140620-009 + monodi	Hexa	0.1350 + 0.0150	50	55	6	9.4	2.4	17.8	33.8	126

4	PGE 20140620-009 + monodi	Hexa	0.1275 + 0.0275	50	55	9.2	13.1	3.4	25.7	37.1	146
5	PGE 20140620-009 + monodi	Hexa	0.09 + 0.06	50	55	17.2	22.1	5.8	45.1	45.6	211
6	PGE 20140620-009	Hexa	0.1	33	55	2.3	5.2	1.3	8.8	32.3	91
7	PGE 20140620-009 + monodi	Hexa	0.08 + 0.02	33	55	9.8	13.7	3.6	27.1	37.9	112
8	PGE 20141208-074	Tri	0.15	50	55	0	0	0	0	29.6	150
9	PGE 20140620-009	Hexa	0.1	15	55	2.3	5.2	1.3	8.8	29.9	94
10	PGE 20140620-009	Hexa	0.15	50	55	2.3	5.2	1.3	8.8	35.8	122

The droplet size distribution for samples 1 to 5 is shown in Figure 1 in which the D50.0 and D97.5 results are plotted.. The droplet size depends linearly on the total content of mono-, di- and triglyceride in the PGE. The droplet size distribution for samples 6 and 7 is shown in Figure 2 in which the D50.0 and D97.5 results are plotted. The droplet size increases with the total content of mono-, di- and triglyceride in the PGE.

Samples 1 to 5 reveal that an increased content of mono-, di- and triglycerides in PGE reduces the emulsification power of the PGE. This is seen from the increase in water droplet size of the fuel emulsions with 50% water content and 0.15% total emulsifier dosage.

Samples 6, 7 and 9 provide similar results with lower water content of 33% (sample 6 and 7) and 15% (sample9) and 0.1% total emulsifier dosage

The PGE in samples 1-7and 9 are based on hexaglycerol, where the PGE in sample 8 is based on purified triglycerol resulting in very low mono-, di- and triglyceride level. For sample 8 is also seen very small water droplet size

Sample 10 is comparable with sample 1. The difference being that the emulsifier was added to the water phase and not to the MGO as in sample 1. Sample 10 produces

slightly larger water droplets, but still with an sufficient emulsion stability without expelled free water

The results obtained were positive compared to the materials of WO2013/001064 which contained significantly higher levels of glycerides. Polyglycerol PGE 2526/160 of WO2013/001064 was prepared from 340g Oleic acid 90%, 102g Polyglycerol, 37g Glycerol and 1.75g 50% NaOH in water. The preparation in the presence of glycerol would result in an expected total mono-di-triglyceride content of approximately 30%.

Triglycerol PGE 2526/159 of WO2013/001064 was prepared from 340g Oleic acid 90%, 108g Triglycerol, and 37g Glycerol. The preparation in the presence of glycerol would result in an expected total mono-di-triglyceride content of approximately 25%

All publications mentioned in the above specification are herein incorporated by 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 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

(b) one or more polyglycerol esters of a fatty acid;

wherein the fuel composition contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

2. A fuel composition according to claim 1 wherein the fuel composition contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 9 wt.%, based on the total content of polyglycerol esters of a fatty acid, monoglycerides, diglycerides and triglycerides.

3. A fuel composition according to any one of the preceding claims wherein the polyglycerol composition used to form the polyglycerol esters of a fatty acid comprises triglycerol in an amount of from 9 to 55 wt. % based on the combined weight of the polyglycerols.

4. A fuel composition according to any one of claims 1 to 3wherein the polyglycerol composition used to form the polyglycerol esters 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.

5. A fuel composition according to any one of the preceding claims wherein the polyglycerol ester is an ester of at least one fatty acid selected from C12 to C22 fatty acids.

6. A fuel composition according to any one of the preceding claims wherein the polyglycerol ester is an ester of at least oleic acid.

7. A fuel composition according to any one of the preceding claims wherein the fatty acid composition used to form the polyglycerol ester of a fatty acid comprises oleic acid in an amount of least 70 wt. % based on the combined weight of the fatty acids.

8. 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 960 to 1170 mg KOH/g.

9. 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 20°C of from 1.493 to 1.497.

10. 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 0.2 wt.% based on the total fuel composition.

11. A fuel composition according to any one of the preceding claims, wherein the fuel composition further comprises (c) water in an amount of from 10 to 70 wt.% based on the total fuel composition.

12. A method for improving the stability of a fuel composition containing (a) fuel and (c) water, the method comprising

mixing (b) a polyglycerol ester of a fatty acid with the fuel and water to form a fuel composition,

wherein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

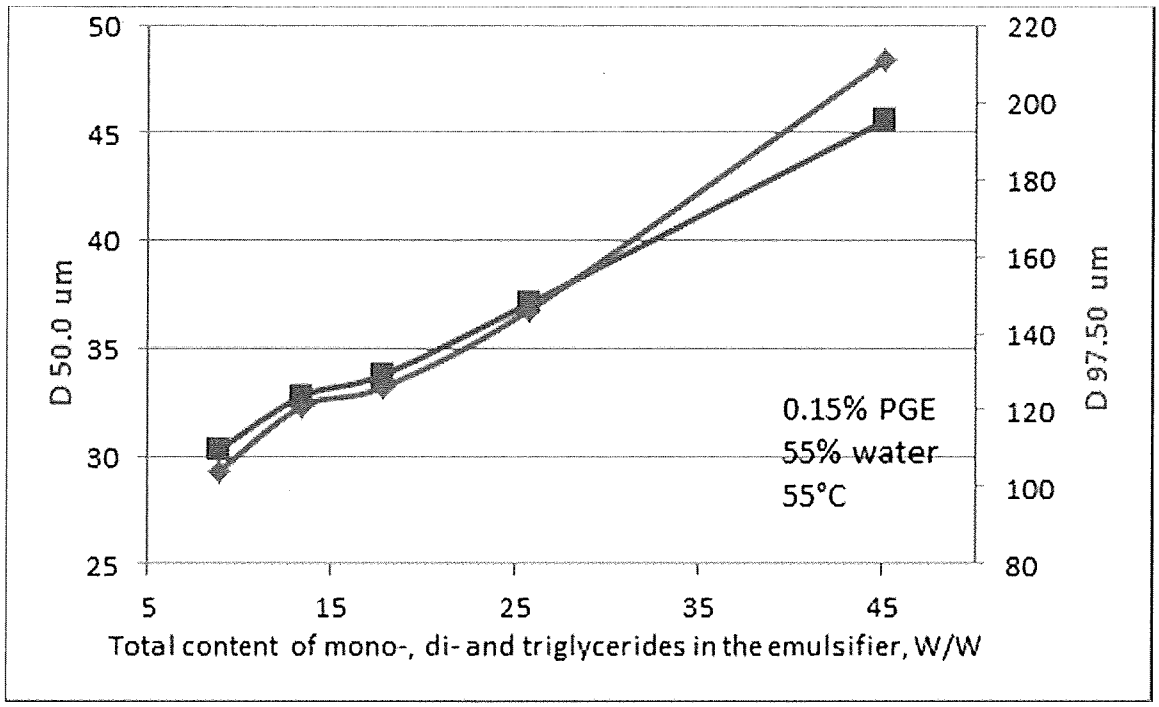
13. A method according to claim 12, characterised by the features of any one of claims 2 to 11.

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

wherein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides, and the polyglycerol ester is an ester of a mixture of fatty acids present in an amount of no greater than 0.5 wt.% based on the total fuel composition.

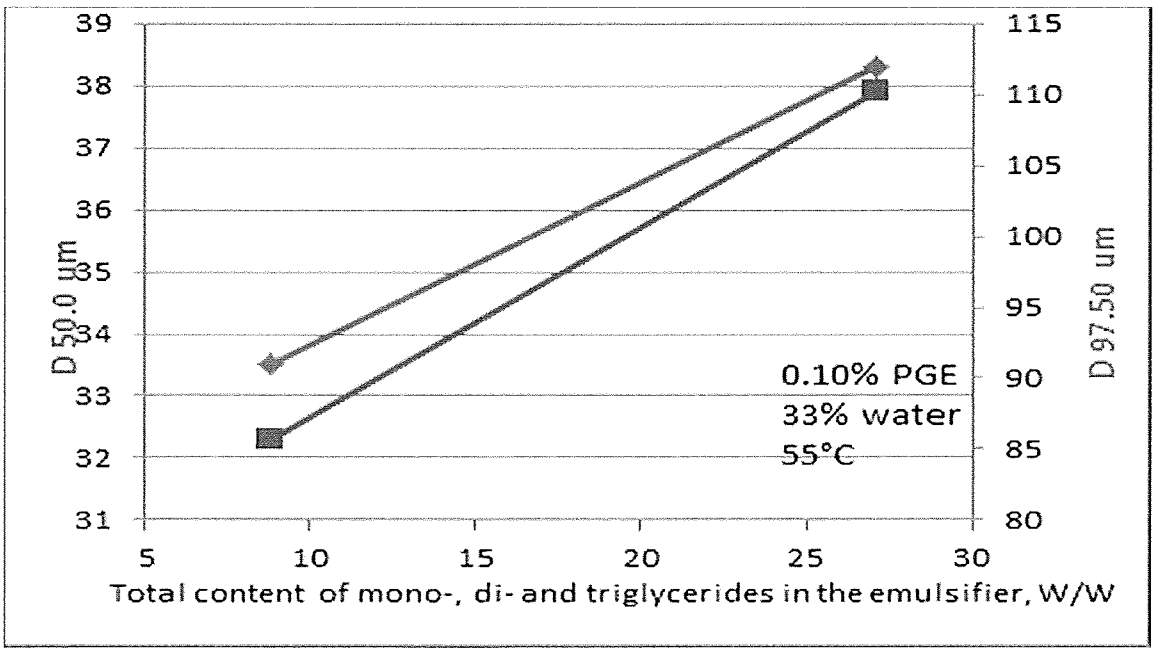
15. A kit for preparing a fuel composition as defined in any one of claims 1 to 11, the kit comprising

a polyglycerol ester of a fatty acid; wherein the polyglycerol ester contains monoglycerides, diglycerides and triglycerides in a combined amount of less than 10 wt.%, based on the total content of polyglycerol ester of a fatty acid, monoglycerides, diglycerides and triglycerides.



■= *D.50.0;* ♦= *D97.5*

Figure 1



■= *D.50.0;* ♦= *D97.5*

Figure 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/056779

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10L1/19 C10L1/198 C10L1/32
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/152309 A1 (OLEON [BE]; VERHAEGHE BEN [BE]; VAN HECKE LIEVEN [BE]; PACKET DIRK [BE]) 15 November 2012 (2012-11-15) page 4, line 22 - page 5, line 4 page 6, line 7 - line 28 page 9, line 27 - page 10, line 5 page 11, line 25 - line 32 examples; tables 1, 2, 5	1-3,5-7, 10,15
X	GB 2 307 697 A (EXXON RESEARCH ENGINEERING CO [US]) 4 June 1997 (1997-06-04) example	1,2,5-7, 10,15
X	WO 2010/010952 A1 (TAIYO KAGAKU KK [JP]; KATO HIROYUKI; ITO NAOTO; SAKAMOTO YUUJI; TAKASE) 28 January 2010 (2010-01-28) abstract	1,2,5,6, 10,15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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Date of the actual completion of the international search	Date of mailing of the international search report
25 May 2016	05/07/2016

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/056779

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