[0007] For an oil-in-water emulsion to be used successfully as a fuel, for example as a marine fuel, it must be robust to both storage (static) stability and handling (dynamic) stability. Although preparation of emulsion fuels has been previously described in some of the documents mentioned above, the stability requirements for their subsequent use have not been established.

[0008] It is an advantage of the present invention that the oil-in-water emulsions of the present invention exhibit reduced levels of sedimentation on storage.

[0009] Accordingly, an embodiment of the invention provides an oil-in-water emulsion comprising an oil phase; an aqueous phase; a primary surfactant; and a polymeric stabiliser selected from cationic polymers, and in particular cationic polymers containing monomers comprising dialkylaminoalkyl acrylate or dialkylaminoalkyl methacrylate quaternary salts, or dialkylaminoalkylacrylamides or methacrylamides and their quaternary salts; wherein the oil phase is dispersed in the aqueous phase; and wherein in the oil-in-water emulsion has the following characteristics:

- an average droplet size (D[4,3]) in the range of from 3 to 15 μm;
- less than 3wt% of the droplets have a particle size of greater than 125 μm;
- a viscosity of greater than 50, preferably greater than 100, and up to 700 mPas at 50 °C (±10%) and 20 s^{-1} (±10%);

a static stability of less than 5% residue after centrifugation at 50°C (±10%) and 2000g (± 10%) for 30 minutes (± 10%).

[0009a] Disclosed herein is an oil-in-water emulsion comprising an oil phase; an aqueous phase; from 0.05 to 0.6 wt% of a primary surfactant selected from one or more from the group consisting of fatty alkyl amines, ethoxylated fatty alkylamines, ethoxylated fatty alkyl monoamines, methylated fatty alkyl monoamines, methylated fatty alkyl amines, and quaternary fatty alkyl amines; up to 0.25 wt% of a polymeric stabiliser, wherein the polymeric stabiliser comprises one or more cationic polymers, and in particular cationic polymers containing monomers comprising dialkylaminoalkyl acrylate or dialkylaminoalkyl methacrylate quaternary salts, or dialkylaminoalkylacrylamides or methacrylamides and their quaternary salts; and an acid; wherein the oil phase is dispersed in the aqueous phase; wherein the emulsion and/or the aqueous phase has a pH in the range of from 2 to 6; and wherein the oil-in-water emulsion has the following characteristics:

- an average droplet size (D[4,3]) in the range of from 3 to 15 µm, wherein the average droplet size is expressed as the Volume Moment Mean and is measured using light scattering techniques;
- less than 3wt% of the droplets have a particle size of greater than 125 µm, wherein droplet size is measured using light scattering techniques;
- a viscosity of greater than 50 and up to 700 mPas at 50 ºC ±10% and 20 s^{-1} ±10%, wherein viscosity is measured on a Malvern Kinexus™ instrument; and
- a static stability of less than 5% residue after centrifugation at 50ºC ±10% and 2000g ±10% for 30 minutes ±10%.

[0010] An emulsion having the above characteristics can have a dynamic stability of less than 0.30 µm increase in mean (D[4,3]) droplet size per minute at 50°C (±10%).

[0011] An embodiment of the invention provides an oil-in-water emulsion comprising an oil phase; an aqueous phase; a polymeric stabiliser, wherein the polymeric stabiliser is selected from cationic polymers, and in particular cationic polymers containing monomers comprising dialkylaminoalkyl acrylate or dialkylaminoalkyl methacrylate quaternary salts, or dialkylaminoalkylacrylamides or methacrylamides and their quaternary salts; and a primary surfactant, selected from one or more from the group consisting of fatty alkyl amines, ethoxylated fatty alkylamines, ethoxylated fatty alkyl monoamines, methylated fatty alkyl monoamines, methylated fatty alkyl amines, and quaternary fatty alkyl amines; wherein the oil phase is dispersed in the aqueous phase; and wherein the oil-in-water emulsion has the following characteristics:

- an average droplet size (D[4,3]) in the range of from 3 to 15 μm;
- less than 3wt% of the droplets have a particle size of greater than 125 μm; and
- a viscosity of greater than 50 and up to 700 mPas at 50 °C ±10% and 20 s^{-1} ±10%.

[0012] An emulsion having such characteristics can result in high static and dynamic stability, as set out above, in addition to reduced sedimentation on storage

[0013] In an embodiment the invention provides a process for preparing the oil-in-water emulsion fuel comprising the steps of:

- heating a hydrocarbon-containing oil;
- mixing water and one or more chemical additives to form an aqueous solution; and

blending the hydrocarbon residue and the aqueous solution under conditions sufficient to form an oil-in-water emulsion having the above characteristics.

[0014] Values of parameters are sometimes expressed in terms of a particular value ± a percentage. This means that the value of that parameter can be either the value specified, or a range of values either side of the specified value, calculated from the percentage. For example, a viscosity of greater than 50, preferably greater thanlOO and up to 700 mPas at 50 °C (±10%)) and 20 $s^{"1}$ (±10%) is referred to above. This means that the viscosity is greater than 50, preferably greater than 100, and up to 700 mPas, at a temperature that is either 50°C, or in the range of from 45 to 55°C, and at a shear rate that is either 20 $s^{"1}$, or in the range of from 18-22 $s^{"1}$. Similarly, a static stability of less than 5% residue after centrifugation at 50°C (±10%) and 2000g (±10%) for 30 minutes (±10%) means that the static stability is such that less than 5% residue (by weight) is produced after centrifugation at a temperature that is either 50°C or in the range of from 45-55°C, at a g-force of either 2000g or in the range of from 1800-2200g, over a time period that is 30 minutes or in the range of from 27-33 minutes.

[0015] The oil-in-water emulsion of the invention may be other than a gas-in-oil-in- water emulsion.

[0016] The oil-in-water emulsion of the invention may be one in which the oil phase is substantially free from entrained bubbles or pockets of gas.

[0017] Disclosed herein is a fuel composition comprising or consisting of the oil-in-water emulsion as defined herein.

Brief Description of the Drawings

[0017] The present invention will now be described with reference to the accompanying drawings, in which:

CLAIMS

1. An oil-in-water emulsion comprising an oil phase; an aqueous phase; from 0.05 to 0.6 wt% of a primary surfactant selected from one or more from the group consisting of fatty alkyl amines, ethoxylated fatty alkylamines, ethoxylated fatty alkyl monoamines, methylated fatty alkyl monoamines, methylated fatty alkyl amines, and quaternary fatty alkyl amines; up to 0.25 wt% of a polymeric stabiliser, wherein the polymeric stabiliser comprises one or more cationic polymers, and in particular cationic polymers containing monomers comprising dialkylaminoalkyl acrylate or dialkylaminoalkyl methacrylate quaternary salts, or dialkylaminoalkylacrylamides or methacrylamides and their quaternary salts; and an acid; wherein the oil phase is dispersed in the aqueous phase; wherein the emulsion and/or the aqueous phase has a pH in the range of from 2 to 6; and wherein the oil-in-water emulsion has the following characteristics:

- an average droplet size (D[4,3]) in the range of from 3 to 15 µm, wherein the average droplet size is expressed as the Volume Moment Mean and is measured using light scattering techniques;
- less than 3wt% of the droplets have a particle size of greater than 125 µm, wherein droplet size is measured using light scattering techniques;
- a viscosity of greater than 50 and up to 700 mPas at 50 °C ±10% and 20 s^{-1} ±10%, wherein viscosity is measured on a Malvern Kinexus™ instrument; and
- a static stability of less than 5% residue after centrifugation at 50°C ±10% and 2000g ±10% for 30 minutes ±10%.

2. The oil-in-water emulsion according to claim 1, having a dynamic stability of less than 0.30 µm increase in mean (D[4,3]) droplet size per minute at 50°C ±10%.

3. The oil-in-water emulsion according to claim 1 or 2, additionally comprising a secondary surfactant.

4. The oil-in-water emulsion according to claim 3, comprising one or more secondary surfactants, in which at least one secondary surfactant is selected from one or more lignin amines.

5. The oil-in-water emulsion according to any preceding claim, comprising in the range of from greater than 0.3 and up to 0.7 wt% secondary surfactant.

6. The oil-in-water emulsion according to any preceding claim, in which the oil of the oil-phase is a hydrocarbon-containing oil having a viscosity of up to 300 000 cSt at 100 °C.

7. The oil-in-water emulsion according to any preceding claim, in which the oil of the oil-phase is a hydrocarbon residue derived from one or more of; processed heavy crude oil or natural bitumen; refinery atmospheric distillation; refinery vacuum distillation; refinery visbreaking, thermal cracking or steam cracking; refinery cat-cracking; refinery hydroprocessing and hydrocracking; and de-asphalting processes; and/or the hydrocarbon is a hydrocarbon residue selected from those having Chemical Abstracts Service (CAS) Registry Numbers 8052-42-4, 64741-45-3, 64741-56-6, 64741-67-9, 64741-75-9, 64741-80-6, 64742-07-0, 64742-78-5, 64742-85-4, 68748-13-7, 68783-13-1, 70913-85-8, 91995-23-2 or 92062-05-0.

8. The oil-in-water emulsion according to any preceding claim wherein the polymeric stabiliser is selected from cationic polymers comprising at least one cationic monomer selected from the group of dialkylaminoalkyl acrylate or dialkylaminoalkyl methacrylate quaternary salts such as dimethylaminoethyl acrylate methyl chloride quaternary salt, dimethylaminoethyl acrylate methyl sulfate quaternary salt, dimethylaminoethyl acrylate benzyl chloride quaternary salt, dimethylaminoethyl acrylate sulfuric acid salt, dimethylaminoethyl acrylate hydrochloric acid salt, dimethylaminoethyl methacrylate methyl chloride quaternary salt, dimethylaminoethyl methacrylate methyl sulfate quaternary salt, dimethylaminoethyl methacrylate benzyl chloride quaternary salt, dimethylaminoethyl methacrylate sulfuric acid salt, dimethylaminoethyl methacrylate hydrochloric acid salt, or dialkylaminoalkylacrylamides or methacrylamides and their quaternary salts such as acrylamidopropyltrimethylammonium chloride, dimethylaminopropyl acrylamide methyl sulfate quaternary salt, dimethylaminopropyl acrylamide methyl saulfate quaternary salt, dimethylaminopropyl acrylamide sulfuric acid salt, dimethylaminopropyl acrylamide hydrochloride salt, methacrylamidopropyltrimethylammonium chloride, dimethylaminopropyl methacrylamide methyl sulfate quaternary salt, dimethylaminopropyl methacrylamide sulfuric acid salt, dimethylaminopropyl methacrylamide hydrochloric acid

salt, diethylaminoethylacrylate, diethylaminoethylmethacrylate, diallyldimethylammonium chloride, and diallyldimethylammonium chloride.

9. The oil-in-water emulsion according to any preceding claim comprising one or more further polymeric stabilisers, at least one of which is selected from the group consisting of alkyl hydroxyalkyl cellulose ethers, guar gum, starch and starch derivatives, hydroxyethyl cellulose and ethyl hydroxyl ethyl cellulose.

10. The oil-in-water emulsion according to any preceding claim, comprising one or more organic acids.

11. The oil-in-water emulsion according to claim 10, in which at least one organic acid is selected from methanesulfonic acid and formic acid.

12. A fuel composition comprising or consisting of the oil-in-water emulsion of any preceding claim.