Emulsifier package with quaternary ammonium surfactant for fuel emulsion

Description

The present invention relates to a fuel emulsion for powering a diesel engine comprising water, a fuel, and an emulsifier package, which comprises a quaternary ammonium surfactant. It further relates to a method for powering a diesel engine with the fuel emulsion comprising the step of preparing the fuel emulsion by emulsifying a fuel and water in the presence of the emulsifier package; and to an emulsifier package for emulsifying a fuel and water comprising a quaternary ammonium surfactant which is obtainable by reacting a quaternizable nitrogen compound comprising at least one quaternizable, especially tertiary, amino group with a quaternizing agent which converts the at least one quaternizable, especially tertiary, amino group to a quaternary ammonium group, where the quaternizing agent is a hydrocarbyl epoxide in combination with a free hydrocarbyl-substituted polycarboxylic acid, and at least one nonionic surfactant which is an alkoxylate.

Aqueous fuel emulsions are known for powering diesel engines.

Object of the present disclosure was to find an emulsifier package for fuel emulsions, which is cheap, easy to prepare, storage stable, based on commercial available emulsifiers, based only on carbon, hydrogen, nitrogen and oxygen, and allow for fast and easy emulsification even with low shear forces. The emulsifier package should result in a low foaming fuel emulsion, it should have a low cloud point, provide corrosion protection, have low foaming, improve filterability of the emulsion, and reduce precipitate when mixing the fuel with water. The emulsifier package should stabilize the fuel emulsion at high water concentrations, at various temperatures and pressures, with various types of water.

In one ~~aspect~~example, the present disclosure refers to a fuel emulsion for powering a diesel engine comprising

- water,
- a fuel, and
- an emulsifier package, which comprises a quaternary ammonium surfactant.

In an aspect, there is provided a fuel emulsion for powering a diesel engine comprising

- water,
- a fuel, and
- an emulsifier package, which comprises

- a quaternary ammonium surfactant and
- at least two nonionic surfactants which are alkoxylates selected from ethoxylates of fatty amide, castor oil ethoxylate, ethoxylated fatty alcohol.

In another aspect, the present disclosure refers to a method for powering a diesel engine with a fuel emulsion comprising the step of preparing the fuel emulsion by emulsifying a fuel and water in the presence of the emulsifier package as defined above.

In yet another ~~aspect~~examplet, the present disclosure refers to an emulsifier package for emulsifying a fuel and water comprising

- a quaternary ammonium surfactant which is obtainable by reacting a quaternizable nitrogen compound comprising at least one quaternizable, especially tertiary, amino group with a quaternizing agent which converts the at least one quaternizable, especially tertiary, amino

group to a quaternary ammonium group, where the quaternizing agent is a hydrocarbyl epoxide in combination with a free hydrocarbyl-substituted polycarboxylic acid, and

- at least one nonionic surfactant which is an alkoxylate.

In another aspect, there is provided an emulsifier package for emulsifying a fuel and water comprising

- a quaternary ammonium surfactant which is obtainable by reacting a quaternizable nitrogen compound comprising at least one quaternizable, especially tertiary, amino group with a quaternizing agent which converts the at least one quaternizable, especially tertiary, amino group to a quaternary ammonium group, where the quaternizing agent is a hydrocarbyl epoxide in combination with a free hydrocarbyl-substituted polycarboxylic acid, and
- at least two nonionic surfactants which are alkoxylates selected from ethoxylates of fatty amide, castor oil ethoxylat, and ethoxylated fatty alcohol.

The **fuel** usually comprise hydrocarbons, such as alkanes, cycloalkanes and aromatics. The fuel may be obtained from petroleum distillation as destillate or residue. The fuels is usually a liquid fluel. Examples of fuels are gasoline, diesel or biodiesel or mixtures thereof, wherein gasoline or diesel are preferred. In particular the fuel is diesel. The gasoline may contain mainly C4 to C12 hydrocarbons of alkanes, alkenes and cycloalkanes. The diesel may contain saturated hydrocarbons and aromatic hydrocarbons. The biodiesel typically includes lower alkyl fatty acid esters, prepared, for example, by transesterifying trigycerides with lower alcohols, e.g. methanol or ethanol.

The viscosity of the fuel can vary in a broad range, such as in the range from 1 to 10,000 mm^2/s at 40 °C (ISO 3104) or 1 to 1000 mm^2/s at 50°C (ISO 3104).

The fuel may be a **marine fuel**, such as MGO (Marine gas oil), MDO (Marine diesel oil), IFO (Intermediate fuel oil), MFO (Marine fuel oil), or HFO (Heavy fuel oil). Further examples for marine fuel are IFO 380 (an Intermediate fuel oil with a maximum viscosity of 380 centistokes (<3.5% sulphur)), IFO 180 (an Intermediate fuel oil with a maximum viscosity of 180 centistokes (<3.5% sulphur)), LS 380 (a Low-sulphur (<1.0%) intermediate fuel oil with a maximum viscosity of 380 centistokes), LS 180 (a Low-sulphur (<1.0%) intermediate fuel oil with a maximum viscosity of 180 centistokes), LSMGO (a Low-sulphur (<0.1%) Marine Gas Oil, which is to often be used in European Ports and Anchorages according to EU Sulphur directive 2005/33/EC), or ULSMGO (a Ultra-Low-Sulphur Marine Gas Oil, also referred to as Ultra-Low-Sulfur Diesel (sulphur 0.0015% max). Further suitable marine fuels are according to DIN ISO 8217 of the

category ISO-F- DMX, DMA, DFA, DMZ, DFZ, or DFB, or ISO-F RMA, RMB, RMD, RME, RMG, or RMK. Further suitable marine fuel is distillate marine diesel or residual marine diesel.

The viscosity of the fuel, such as the marine fuel, can vary in a broad range, such as in the range from 1 to 10,000 mm^2/s at 40 °C (ISO 3104) or 1 to 1000 mm^2/s at 50°C (ISO 3104).

The fuel emulsion may contain at least 10, 20, 25, 30, 35, 40, 50 or 60 wt% of the fuel. The fuel emulsion may contain up to 30, 40, 50 or 60 wt% of the fuel. The fuel emulsion may contain 10 to 70 wt%, 20 to 60 wt%, or 30 to 50 wt% of the fuel.

Claims

1. A fuel emulsion for powering a diesel engine comprising
   - water,
   - a fuel, and
   - an emulsifier package, which comprises
     - a quaternary ammonium surfactant and
     - at least two nonionic surfactants which are alkoxylates selected from ethoxylates of fatty amide, castor oil ethoxylate, ethoxylated fatty alcohol.

~~2. The fuel emulsion according to claim 1 where the emulsifier package comprises at least one nonionic surfactant which is an alkoxylate.~~

~~3. The fuel emulsion according to claim 1 or 2 where the emulsifier package comprises at least two nonionic surfactants which are alkoxylates selected from ethoxylates of fatty amide, castor oil ethoxylate, ethoxylated fatty alcohol.~~

~~4.~~2. The fuel emulsion according claim 1~~to any of claims 2 or 3~~ where the emulsifier package comprises at least 60 wt% of the nonionic surfactant.

~~5.~~3. The fuel emulsion according to any of claims 1 or 2~~ to 4~~ where the quaternary ammonium surfactant is a reaction product obtainable by
   - reacting a quaternizable nitrogen compound comprising at least one quaternizable, especially tertiary, amino group with a quaternizing agent which converts the at least one quaternizable, especially tertiary, amino group to a quaternary ammonium group,
   - wherein the quaternizing agent is a hydrocarbyl epoxide in combination with a free hydrocarbyl-substituted polycarboxylic acid.

~~6.~~4. The fuel emulsion according to any of claims 1 to 3~~5~~ where the emulsifier package comprises 1 to 40 wt% of the quaternary ammonium surfactant.

~~7.~~5. The fuel emulsion according to any of claims 1 to 4~~6~~ where the fuel emulsion comprises the emulsifier package in an amount of 0.05 to 0.5 wt% based on the fuel, preferably diesel.

~~8.~~6. The fuel emulsion according to any of claims 1 to ~~5~~7 where the fuel emulsion is an oil-in-water emulsion.

~~9.~~7. The fuel emulsion according to any of claims 1 to ~~6~~8 where the fuel emulsion comprises 50 to 80 wt% water.

~~10.~~8. The fuel emulsion according to any of claims 1 to ~~7~~9 where the fuel is marine fuel.

9. The fuel emulsion according to claim 8, wherein the marine fuel is selected from the group consisting of MGO (Marine gas oil), MDO (Marine diesel oil), IFO (Intermediate fuel oil), MFO (Marine fuel oil), or HFO (Heavy fuel oil), IFO 380 (an Intermediate fuel oil with a maximum viscosity of 380 centistokes (<3.5% sulphur)), IFO 180 (an Intermediate fuel oil with a maximum viscosity of 180 centistokes (<3.5% sulphur)), LS 380 (a Low-sulphur (<1.0%) intermediate fuel oil with a maximum viscosity of 380 centistokes), LS 180 (a Low-sulphur (<1.0%) intermediate fuel oil with a maximum viscosity of 180 centistokes), LSMGO (a Low-sulphur (<0.1%) Marine Gas Oil, which is to often be used in European Ports and Anchorages according to EU Sulphur directive 2005/33/EC), or ULSMGO (a Ultra-Low-Sulphur Marine Gas Oil, also referred to as Ultra-Low-Sulfur Diesel (sulphur 0.0015% max), marine fuels are according to DIN ISO 8217 of the category ISO-F- DMX, DMA, DFA, DMZ, DFZ, or DFB, or ISO-F RMA, RMB, RMD, RME, RMG, or RMK, distillate marine diesel or residual marine diesel.

10. The fuel emulsion according to claim 8, wherein the fuel contains less than 1, 0.5, 0.2, or 0.1 wt% sulfur.

11. A method for powering a diesel engine with a fuel emulsion comprising the step of preparing the fuel emulsion by emulsifying a fuel and water in the presence of the emulsifier package as defined in the prec~~e~~eding claims.

12. An emulsifier package for emulsifying a fuel and water comprising

- a quaternary ammonium surfactant which is obtainable by reacting a quaternizable nitrogen compound comprising at least one quaternizable, especially tertiary, amino group with a quaternizing agent which converts the at least one quaternizable, especially tertiary, amino group to a quaternary ammonium group, where the quaternizing agent is a hydrocarbyl epoxide in combination with a free hydrocarbyl-substituted polycarboxylic acid, and
- at least two nonionic surfactants which are alkoxylates selected from ethoxylates of fatty amide, castor oil ethoxylat, and ethoxylated fatty alcohol~~at least one nonionic surfactant which is an alkoxylate~~.

~~13. The emulsifier package according to claim 12 comprising at least two nonionic surfactants which are alkoxylates selected from ethoxylates of fatty amide, castor oil ethoxylat, and ethoxylated fatty alcohol.~~

~~14.~~13. The emulsifier package according to claim 12 ~~or 13~~ comprising 1 to 40 wt% of the quaternary ammonium surfactant.

~~15.~~14. The emulsifier package according to any of claims 12 or 13~~to 14~~ comprising at least 60 wt% of the at least two nonionic surfactants.