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(54) LPG FUEL COMPOSITIONS, ADDITIVES THEREFOR AND USES THEREOF

(57) The present invention relates to a hydrocarbon fuel composition comprising liquefied petroleum gas and an additive selected from the compounds having the following formula (I) and mixtures thereof:

$$R\text{-}Ph\text{-}(OCH_2CH_2)n\text{-}OH \qquad (I)$$

wherein
Ph denotes a benzene ring,
R represents a linear or branched saturated or unsaturated hydrocarbon chain comprising from 8 to 24 carbon atoms, which may be substituted or not substituted, and
n represents a number ranging from 1 to 10.

The invention further concerns and additive composition comprising compounds of formula (I) and phenolic antioxidant agent(s), as well as oxyfuel processes and methods of operating motor vehicles and gas burners involving such fuel compositions.

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Description

[0001] The present invention relates to a novel fuel composition comprising liquefied petroleum gas and one or more specific additives. Such a fuel composition is useful in several different applications. Preferred applications include feeding motor vehicles and in particular two- or three-wheeled motor vehicles, feeding gas burners in particular for heating or cooking applications, and oxyfuel-cutting and welding applications.

[0002] The present invention also relates to an additive composition intended to be added to fuels based on liquefied petroleum gas.

[0003] The present invention also relates to a method of operating a motor vehicle wherein the motor is fed with the inventive fuel composition, a method of operating a gas burner wherein the burner is fed with the inventive fuel composition, and a method of cutting and/or welding metallic materials using the inventive fuel composition.

PRIOR ART AND BACKGROUND OF THE INVENTION

[0004] There are many methods for metal cutting available on the market, such as laser, plasma, gas flame, etc. However, due to its low cost, ease of handling and safety gas flame is more popular for metal applications.

[0005] There are mainly three kinds of gases being used as fuels for metal cutting purposes, one is natural gas, second one is acetylene gas, and the third one is propane/propylene gas. Some advantages and drawbacks are associated with these three gases.

[0006] Typically, the density of natural gas is significantly lower than the density of air. On the other hand, the density of acetylene is close to the density of air, while that of propane and propylene gases exceed the density of air. The density of the gas used is important because in case of leak, natural gas is not likely to form low concave buildup and therefore reducing the risks of explosion. Furthermore, the relative density of natural gas is much lower than the density of air. Therefore, the leaked natural gas can be quickly volatilized, which allows a safer use of natural gas in small and relatively closed spaces. The explosion range of natural gas is narrow, as compared with that of acetylene explosion range, so the safety is much higher.

[0007] The ignition point of natural gas is higher than that of acetylene, propane and propylene. Therefore, for igniting natural gas, use should be made of an open flame, so that it is not safe to ignite the gas due to sporadic low-temperature fire.

[0008] Liquefied petroleum gas (also referred to as LPG) exhibits advantages which are similar to those of natural gas when compared with acetylene.

[0009] Additionally, natural gas and LPG are composed of naturally occurring hydrocarbons. Acetylene needs to be produced which consumes a lot of electricity and coke, as well as a lot of pollutants. When acetylene is burned black smoke is produced, which is not the case with natural gas and LPG.

[0010] Oxyfuel processes use oxygen and a fuel gas in order to cut or weld metals. Such processes are essentially based on a chemical reaction between pure oxygen and metal to form metal oxide at an elevated temperature. Such thermal cutting and welding processes are widely used in industry. They allow for example cutting metal plates having thicknesses ranging up to 500 mm or more. The cutting process uses a mixture of oxygen and hydrocarbon fuel gas to preheat the metal to its 'ignition' temperature (for instance 700°C - 900°C for steel) but well below its melting point. A cutting oxygen stream is then directed at the preheated spot, causing rapid oxidation of the heated metal. This generates large amount of heat due to exothermicity of the reaction. This heat supports continued oxidation of the metal as the cut progresses. Combusted gas and the pressurized oxygen jet flush the molten oxide away, exposing fresh surfaces for cutting. The metal in the path of the oxygen jet burns. The cut progresses, making a narrow slot, or kerf, through the metal.

[0011] The fuel gas mainly used in oxyfuel processes has been acetylene, because il allows reaching the highest flame temperatures and achieving the highest cutting/welding speed. Other fuel cutting or welding fuel gases are propane, propylene, natural gas, etc. However, the flame temperatures produced by these fuels (in oxygen) are substantially lower compared to acetylene. For example, the maximum flame temperatures for propane and natural gas in oxygen are about 2810°C and 2770°C respectively whereas acetylene allows reaching flame temperatures up to 3160°C.

[0012] However, as explained hereabove acetylene has many drawbacks. In particular it is expensive, difficult to store and to transport, requires the use of almost pure oxygen for cutting ferrous metals and forms persistently adherent slag. Back firing is another drawback often encountered while using an oxyacetylene flame. As acetylene explodes when subjected to high pressures, oxyacetylene flame cannot be used under deep water at depths greater than 20 feet under water.

[0013] The advantages of liquefied petroleum gas (LPG) include low cost, low explosivity, low slag formation, easy handling, lower operating pressures.

[0014] Thus, there is a need to provide alternative fuels which can replace acetylene in oxyfuel processes without decreasing the performances thereof.

[0015] A number of attempts have been made to replace acetylene by LPG in oxyfuel processes and to improve the properties of LPG fuels by adding additives.

[0016] For example, WO 2008/072254 discloses a hydrocarbon fuel composition useful in oxyfuel processes comprising at least 99% by weight of a base gas such as liquefied petroleum gas and additives comprising 2 to 50 ppm organometallic compound, 100 to 5000 ppm aniline or substituted aniline and 100 to 5000 ppm toluidine.

[0017] WO 2020/208646 discloses an additive composition for oxyfuel applications (in particular wherein the fuel is a liquefied petroleum gas), comprising:

(a) an organometallic compound;
(b) a nitrogen-containing compound;
(c) an aryl peroxide; and
(d) at least one solvent,

wherein the organometallic compound to the nitrogen-containing compound to the aryl peroxide weight ratio is in a range of 7:0.5:0.5 - 9:1.5:1.5.

[0018] However, due to the presence of organometallic compounds such compositions are toxic for the environment and the burning thereof generates polluting emissions.

[0019] Furthermore, there still remains a need for improving the intrinsic performances of LPG fuels such as burning efficiency.

[0020] Thus, in view of the defects existing in the prior art, one object of the present invention is to provide a LPG composition useful for cutting and welding applications, which provides an increased efficiency and in particular an increased burning speed.

[0021] The composition shall also be suitable for use in other applications including as a fuel for motor vehicles and for burners.

OBJECT OF THE INVENTION

[0022] The Applicant has now discovered that LPG compositions containing a particular additive as defined below provided unexpected benefits when used as a fuel in an oxyfuel process.

[0023] The Applicant has also discovered that the benefits of such a fuel composition were not limited to oxyfuel applications, and that the composition could also be used as a fuel for other applications such as -and not limited to- fuel for motor vehicles for example for two-wheeled and three-wheeled motor vehicles, and fuel for feeding gas burners in particular for heating and cooking applications.

[0024] Thus, one object of the present invention is a hydrocarbon fuel composition comprising liquefied petroleum gas and an additive selected from the compounds having formula (I) below and mixtures of such compounds:

$$R\text{-}Ph\text{-}(OCH_2CH_2)_n\text{-}OH \qquad (I)$$

wherein

Ph denotes a benzene ring,
R represents a linear or branched saturated or unsaturated hydrocarbon chain comprising from 8 to 24 carbon atoms, which may be substituted or not substituted, and
n represents a number ranging from 1 to 10.

[0025] The fuel composition according to the invention is easy to produce and to handle.

[0026] In oxyfuel processes, it provides a high temperature and pointed flame which allows achieving very efficient cutting and welding of metal pieces. More specifically, the additive of formula (I) provides a catalytic combustion-supporting effect, so that the flame temperature is increased, the preheating time is reduced and the burning speed is increased. Accelerating the oxidation (burning) of iron and oxygen increases the cutting speed, reduces the consumption of fuel and of oxygen, reduces the CO emissions and provides a better environmental protection and safety.

[0027] According to a preferred embodiment, the fuel composition of the invention further contains one or more anti-oxidant agents selected from the compounds comprising in their structure an alkyl-phenol group and/or phosphate or phosphite antioxidant agent(s).

[0028] Another object of the present invention is an additive composition comprising:

- an additive selected from the compounds having formula (I) below and mixtures of such compounds:

$$R\text{-}Ph\text{-}(OCH_2CH_2)_n\text{-}OH \qquad (I)$$

wherein

Ph denotes a benzene ring,
R represents a linear or branched saturated or unsaturated hydrocarbon chain comprising from 8 to 24 carbon atoms, which may be substituted or not substituted, and n represents a number ranging from 1 to 10, and

- one or more antioxidant agents selected from the compounds comprising in their structure an alkyl-phenol group and/or phosphate or phosphite antioxidant agent(s).

[0029] Another object of the invention is a process for cutting or welding a metallic material wherein a fuel composition as defined above is heated as a flame which is directed to said metallic material with an oxygen jet in order to achieve cutting or welding thereof.

[0030] The present invention also relates to a method of operating a motor vehicle, comprising supplying a fuel composition as defined above to said motor, and burning the fuel composition into the motor.

[0031] The present invention also relates to a method of operating a gas burner, comprising supplying a fuel composition as defined above to said burner, and burning the fuel composition into the burner.

[0032] Other objects, features, aspects and advantages of the invention will become more apparent upon reading the following description and examples.

[0033] In the following, and at least one other indication, the limits of a value range are included within this range, particularly in the expressions "between" and "ranging from ... to ...".

[0034] Moreover, the expressions "at least one" and "at least" used in the present description are respectively equivalent to the expressions "one or more" and "more than or equal to".

[0035] Finally, in a manner known per se, C_N compound or group designates a compound or a group containing in its chemical structure N carbon atoms.

DETAILED DESCRIPTION

The fuel base :

[0036] The fuel composition of the invention contains liquefied petroleum gas (LPG) as base fuel.

[0037] In a manner known per se, LPG consists of a mixture of hydrocarbons containing 3 and 4 carbon atoms, which composition may vary depending from the origin of the LPG. LPG generally contains propane and butanes (n-butane and/or iso-butane). Depending on its source, the LPG may further contain C3 and/or C4 olefins such as propylene, 1-butene, 2-butene, iso-butylene and butadiene.

[0038] The fuel composition of the present invention preferably contains an amount of LPG of at least 90% by weight, more preferably at least 95% by weight, and even more preferably at least 98% by weight, and even better at least 99% by weight, with respect of the total weight of the composition.

[0039] According to a preferred embodiment, the amount of LPG ranges from 90 to 99.9% by weight, more preferably from 95 to 99.5% by weight, with respect of the total weight of the composition.

The additives of formula (I):

[0040] The fuel composition of the invention contains an additive which is selected from the compounds having the following formula (I):

$$R\text{-}Ph\text{-}(OCH_2CH_2)_n\text{-}OH \qquad (I)$$

wherein

Ph denotes a benzene ring,
R represents a linear or branched saturated or unsaturated hydrocarbon chain comprising from 8 to 24 carbon atoms, which may be substituted or not substituted, and
n represents a number ranging from 1 to 10,
and from mixtures of compounds of formula (I).

[0041] The substituents which may be present on said R hydrocarbon chain may be chosen in particular from hydroxy groups (-OH), hydroxyalkyl groups of formula -O-R' wherein R' denotes a C_1 to C_4 alkyl radical, amino groups of formula $-NR_1R_2$ wherein R_1 and R_2 independently one from another denote a hydrogen atom or a C_1 to C_4 alkyl radical.

[0042] According to a preferred embodiment, R represents a linear or branched saturated or unsaturated hydrocarbon group comprising from 8 to 24 carbon atoms, preferably from 10 to 22 carbon atoms, even more preferably from 12 to 18 carbon atoms and even better from 14 to 16 carbon atoms.

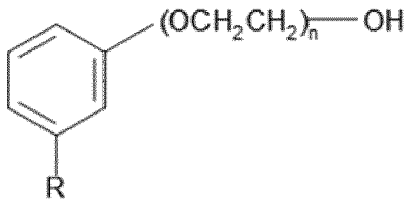
[0043] According to a preferred embodiment, R represents a linear saturated or unsaturated hydrocarbon group.

[0044] By unsaturated, it is referred to hydrocarbon groups including one or more olefinic bond(s) -C=C-, such as two or three olefinic bonds.

[0045] The number n preferably ranges from 1 to 5, preferably from 2 to 4 and most preferably n denotes 2 or 3.

[0046] The benzene ring Ph meets the formula C6H4. The groups -R and $-(OCH_2CH_2)_n-OH$ may be positioned on the benzene ring in ortho, meta or para position relative to each other. The meta position is preferred.

[0047] Thus, according to a preferred embodiment, the compounds of formula (I) are chosen from those having developed formula (Ia) below:



(Ia)

wherein R and n are as defined above, including preferred embodiments detailed hereabove.

[0048] Particularly preferred compounds of formula (Ia) are bis-ethoxylated cardanol, tris-ethoxylated cardanol and mixtures thereof. Tris-ethoxylated cardanol is particularly preferred.

[0049] The fuel composition of the invention contains a total amount of additive(s) of formula (I) preferably ranging from 0.01% to 0.5% by weight, preferably from 0.02% to 0.3% by weight, and most preferably from 0.03 to 0.2% by weight relative to the total weight of the fuel composition.

[0050] According to a preferred embodiment, the fuel composition of the invention contains a total amount of additive(s) of formula (Ia) ranging from 0.01% to 0,5% by weight, preferably from 0.02% to 0.3% by weight, and most preferably from 0.03 to 0.2% by weight relative to the total weight of the fuel composition.

[0051] According to another preferred embodiment, the fuel composition of the invention contains a total amount of bis-ethoxylated cardanol, tris-ethoxylated cardanol and mixtures thereof ranging from 0.01% to 0,5% by weight, preferably from 0.02% to 0.3% by weight, and most preferably from 0.03 to 0.2% by weight relative to the total weight of the fuel composition.

The second additive (phenolic antioxidant agent), optional:

[0052] Preferably, the fuel composition used in accordance with the present invention further comprises a second additive consisting of an antioxidant agent selected from the compounds comprising in their structure an alkyl-phenol group.

[0053] Such antioxidant agents are different from the compounds of formula (I) described above. In particular, by alkyl-phenol group it is meant a phenol group (that is to say, a benzene group substituted by one or more free hydroxy -OH group(s), in particular which is (are) not oxyalkylated), which is substituted by one or more alkyl groups.

[0054] According to a preferred embodiment, said antioxidant agents are selected from compounds comprising one or two phenolic group(s) which are substituted by one or more alkyl groups in C_1 to C_4 and preferably one or more alkyl groups selected from methyl, ethyl and t-butyl (tert-butyl).

[0055] Particularly preferred antioxidant agents are selected from methyl-t-butyl phenols, dimethyl-t-butyl phenols, ethyl-t-butyl phenols, t-butyl phenols, di-t-butyl phenols, tri-t-butyl phenols, di-t-butyl- di-methylphenols.

[0056] Most preferred antioxidant agents are selected from 2,6 di-t-butyl-4 methyl phenol (BHT), 4,6- di-tert-butyl-2-methylphenol, t-butyl hydroquinone (TBHQ), 2,6 di-t-butyl phenol, 2,4 di-t-butyl phenol, 2,4-dimethyl-6-t-butyl phenol, 2,4,6- tri-t-butyl phenol, 2,3,6-trimethyl phenol, 2,4,6-trimethyl phenol, 4,4'-methylene bis(2,6-di-t-butyl phenol) (CAS No. 1 18-82-1), 2,6-di-t-butyl-4-(3,5-di-t-butyl-4-hydroxyphenyl)phenol, and mixtures thereof, and even most preferably from 2,6 di-t-butyl phenol, 2,4 di-t-butyl phenol, 2,6-di-t-butyl-4-(3,5-di-t-butyl-4-hydroxyphenyl)phenol, and mixtures thereof.

[0057] The fuel composition according to the invention may advantageously comprise said phenolic antioxidant agent(s) in a total content ranging from 2 to 500 ppm, preferably from 5 to 250 ppm, and more preferably from 10 to 150 ppm by weight, relative to the total weight of the fuel composition.

The other additives:

[0058] The fuel composition used in accordance with the present invention may also comprise one or more additional additives, different from the additives of formula (I) and of the phenolic antioxidant agents described above.

[0059] According to a preferred embodiment, the fuel composition further contains one or more amino antioxidant agent(s), which may be selected from aliphatic, cycloaliphatic and aromatic amines.

[0060] Mention may be made in particular of 4-alkyl-N-(4-alkylphenyl)anilines such as in particular 4-octyl-N-(4-octylphenyl)aniline and 4-nonyl-N-(4-nonylphenyl)aniline.

[0061] The amino antioxidant agent(s) may be present in a content ranging from 0.5 to 1000 ppm, preferably from 1 to 500 ppm, and more preferably from 2 to 100 ppm by weight, relative to the total weight of the fuel composition.

[0062] According to a preferred embodiment, the fuel composition further contains one or more phosphate or phosphite antioxidant agent(s), which may be selected from tris(alkylphenyl)phosphates and tris(alkylphenyl)phosphites. Mention may be made in particular of tris(2,4-di-tert-butylphenyl)phosphate and tris(2,4-di-tert-butylphenyl)phosphite.

[0063] The phosphate and phosphite antioxidant agent(s) may be present in a total content ranging from 0.2 to 50 ppm, preferably from 0.5 to 25 ppm, and more preferably from 1 to 20 ppm by weight, relative to the total weight of the fuel composition.

[0064] The fuel composition may further contain any other type of additives, which may be chosen among the additives usually used in LPG fuel composition such as in particular lubricity improvers. One skilled in the art will be able to select appropriate additives without departing from the scope of the invention.

The additive composition

[0065] The invention further concerns an additive composition comprising:

- an additive selected from the compounds having formula (I) as described above, and mixtures of such compounds, and
- one or more phenolic antioxidant agent(s) as described above and/or one or more phosphate or phosphite antioxidant agent(s) as described above.

[0066] According to a preferred embodiment, the composition further comprises one or more amino antioxidant agent(s) as described above.

[0067] The descriptions of the compounds of formula (I), of the phenolic, amino, phosphate and phosphite antioxidant agents as detailed above with regard to the fuel composition totally applies to the additive composition of the invention, including preferred compounds and embodiments.

[0068] According to a preferred embodiment, the additive composition contains an organic solvent. Preferred solvents are chosen from aliphatic hydrocarbons, aromatic hydrocarbons such as the solvents available under the commercial names Solvesso, and solvents comprising mixtures or paraffinic and aromatic compounds such as the solvents available under the commercial names Spirdane. Mention may also be made hydrocarbon fractions including naphtha, kerosene, gasoline and diesel fractions.

[0069] According to a preferred embodiment, the additive compositions contains:

- from 1 to 10% by weight and preferably from 2 to 5% by weight of additive(s) selected from compounds of formula (I);
- from 0.05 to 1.5 % by weight of phenolic antioxidant agent(s);
- optionally, one or more amino antioxidant agent(s) in a total amount ranging from 0.1 to 1 % by weight;
- optionally, one or more phosphate or phosphite antioxidant agent(s) in a total amount ranging from 0.01 to 0.1% by weight;
- an organic solvent, in an amount ranging from 85% by weight to 98.5% by weight;

all weight being expressed with regard to the total weight of the additive composition.

The process for cutting or welding metal pieces:

[0070] The process of the invention involves forming a flame by combustion of the composition of the invention and applying said flame together with a jet of oxygen onto pieces of metals in order to achieve cutting or welding thereof.

[0071] The flame heats the metal locally so that it is transformed into its oxide form and the resulting heated metal oxide is pushed off by the jet of oxygen. The higher the flame temperature, the lesser is the pre-heating time, along with faster cutting speed, lower fuel consumption and cleaner cut.

The method of operating a motor vehicle

[0072] The fuel composition of the invention is also perfectly suitable for feeding all types of motors using LPG as fuel, such as in particular motors present in vehicles.

[0073] Such motors include in particular motors of cars, of transport vehicles such as buses, of two-wheels vehicles such as mopeds, scooters, of three-wheels vehicles such as motor rickshaws (tuk-tuk), three-wheels scooters.....

[0074] According to a preferred embodiment, the vehicle is a three-wheels vehicle, and more preferably a motor rickshaw (tuk-tuk).

The method of operating a gas burner

[0075] The fuel composition of the invention is also perfectly suitable for feeding all types of gas burners whether they are used in industrial, collective or domestic applications.

[0076] Such gas burners include for example heating burners and cooking burners, and preferably heating burners.

[0077] The example hereafter only aims at illustrating the present invention, and shall not be interpreted so as to limit its scope.

EXAMPLE

[0078] The trial was conducted using a computer numerical control (CNC) cutting machine, using the following device and conditions:

- CNC machine: Hugong gantry CNC cutting machine, effective cutting size 2800 x 8000;
- Nozzle Type: Koike PNME Nozzle
- Nozzle Dimension: PNME Nozzle No. 4
- Pre-heating Oxygen Pressure : 0.6 MPa
- Cutting Oxygen Pressure: 0.25 MPa
- Fuel Pressure: 0.7 MPa.

[0079] The following additive composition was prepared, using the ingredients detailed in Table 1 below, wherein all amounts are expressed in percentages by weight with regard to the total weight of the additive composition.

Table 1

Ingredient	Amount (% by weight)
tris-ethoxylated cardanol	3
2,6 di-t-butyl phenol	0.85
4-octyl-N- (4 -octylphenyl) aniline	0.5
tris (2, 4-di-tert-butylphenyl)pho sphite	0.02
Spiradane D40 (organic solvent)	95.63

[0080] A fuel composition was prepared by mixing 55 ml of the above additive with 30.45 1 of liquefied petroleum gas.

[0081] The fuel composition was tested for oxy-cutting a 56 mm plate of mild steel, IS:2062 grade.

[0082] The cutting speed was increased step by step while keeping an acceptable quality of surface finish as approved by a cutting expert.

[0083] The composition of the invention allowed achieving a maximum cutting speed of 250 mm/min which is very high, while providing a cut surface having a perfect finish.

Claims

1. A hydrocarbon fuel composition comprising liquefied petroleum gas and an additive selected from the compounds having formula (I) below and mixtures of such compounds:

$$R\text{-}Ph\text{-}(OCH_2CH_2)_n\text{-}OH \qquad (I)$$

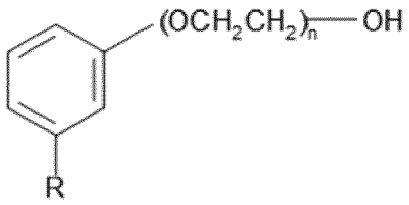
wherein

Ph denotes a benzene ring,
R represents a linear or branched saturated or unsaturated hydrocarbon chain comprising from 8 to 24 carbon atoms, which may be substituted or not substituted, and
n represents a number ranging from 1 to 10.

2. A fuel composition as defined in claim 1, wherein in formula (I) R represents a linear or branched saturated or unsaturated hydrocarbon group comprising from 8 to 24 carbon atoms, preferably from 10 to 22 carbon atoms, even more preferably from 12 to 18 carbon atoms and even better from 14 to 16 carbon atoms.

3. A fuel composition as defined in anyone of the preceding claims, wherein in formula (I) R represents a linear, saturated or unsaturated hydrocarbon group.

4. A fuel composition as defined in anyone of the preceding claims, wherein the compounds of formula (I) are chosen from those having developed formula (Ia) below:



(Ia)

wherein R and n are as defined in anyone of claims 1 to 3.

5. A fuel composition as defined in anyone of the preceding claims, wherein the compounds of formula (I) are chosen from bis-ethoxylated cardanol, tris-ethoxylated cardanol and mixtures thereof, and preferably tris-ethoxylated cardanol.

6. A fuel composition as defined in anyone of the preceding claims, containing a total amount of additive(s) of formula (I), preferably of formula (Ia), ranging from 0.01% to 0.5% by weight, preferably from 0.02% to 0.3% by weight, and most preferably from 0.03 to 0.2% by weight, relative to the total weight of the fuel composition.

7. A fuel composition as defined in anyone of the preceding claims, further containing one or more antioxidant agent(s) selected from the compounds comprising in their structure an alkyl-phenol group, preferably from compounds comprising one or two phenolic group(s) which are substituted by one or more alkyl groups in C_1 to C_4, and more preferably from 2,6 di-t-butyl-4 methyl phenol, 4,6- di-tert-butyl-2-methylphenol, t-butyl hydroquinone, 2,6 di-t-butyl phenol, 2,4 di-t-butyl phenol, 2,4-dimethyl-6-t-butyl phenol, 2,4,6- tri-t-butyl phenol, 2,3,6-trimethyl phenol, 2,4,6-trimethyl phenol, 4,4'-methylene bis(2,6-di-t-butyl phenol), 2,6-di-t-butyl-4-(3,5-di-t-butyl-4-hydroxyphenyl)phenol, and mixtures thereof, and even more preferably from 2,6 di-t-butyl phenol, 2,4 di-t-butyl phenol, 2,6-di-t-butyl-4-(3,5-di-t-butyl-4-hydroxyphenyl)phenol, and mixtures thereof.

8. A fuel composition as defined in claim 7, wherein said one or more antioxidant agent(s) is (are) present in a total content ranging from 2 to 500 ppm, preferably from 5 to 250 ppm, and more preferably from 10 to 150 ppm by weight, relative to the total weight of the fuel composition.

9. A fuel composition as defined in anyone of the preceding claims, further containing one or more phosphate or phosphite antioxidant agent(s), preferably selected from tris(alkylphenyl)phosphates and tris(alkylphenyl)phosphites, and more preferably from tris(2,4-di-tert-butylphenyl)phosphate and tris(2,4-di-tert-butylphenyl)phosphite.

10. A fuel composition as defined in anyone of the preceding claims, containing an amount of liquefied petroleum gas ranging from 90 to 99.9% by weight, more preferably from 95 to 99.5% by weight, with respect of the total weight of the composition.

11. An additive composition comprising :

- an additive selected from the compounds having formula (I) as defined in anyone of claims 1 to 5, and
- one or more antioxidant agent(s) selected from the compounds comprising in their structure an alkyl-phenol group and/or one or more phosphate or phosphite antioxidant agent(s).

12. An additive composition as defined in claim 11, containing:

- from 1 to 10% by weight and preferably from 2 to 5% by weight of one or more additive(s) selected from compounds of formula (I);
- from 0.05 to 1.5 % by weight of one or more phenolic antioxidant agent(s);
- optionally, one or more amino antioxidant agent(s) in a total amount ranging from 0.1 to 1 % by weight;
- optionally, one or more phosphate or phosphite antioxidant agent(s) in a total amount ranging from 0.01 to 0.1% by weight;
- an organic solvent, in an amount ranging from 85% by weight to 98.5% by weight;

all weight being expressed with regard to the total weight of the additive composition.

13. A process for cutting or welding a metallic material comprising forming a flame by combustion of a fuel composition as defined in anyone of claims 1 to 10 and applying said flame together with a jet of oxygen onto pieces of metals in order to achieve cutting or welding thereof.

14. A method of operating a motor vehicle, preferably a two-wheels or a three-wheels vehicle, comprising supplying a fuel composition as defined in anyone of claims 1 to 10 to said motor, and burning the fuel composition into the motor.

15. A method of operating a gas burner, comprising supplying a fuel composition as defined in anyone of claims 1 to 10 to said burner, and burning the fuel composition into the burner.

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 1838

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 782 936 A (RILEY RICHARD A [US]) 21 July 1998 (1998-07-21) * claims 1, 7-9, 11, 13, 19-21, 23; ex. 1-4; col. 2, l. 7-13 *	1-15	INV. C10L1/14 C10L1/183 C10L3/12
X	CN 1 523 085 A (JIHUA GROUP CO LTD [CN]) 25 August 2004 (2004-08-25) * claims 1, 4-8; p. 4; ex. 4-5 *	1-15	ADD. C10L1/16 C10L1/26
X	CN 1 431 282 A (XU LIANYUN [CN]) 23 July 2003 (2003-07-23) * claims 1, 3; ex. 1-8; abstract *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

C10L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	10 June 2022	Greß, Tobias

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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10-06-2022

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US 5782936 A	21-07-1998	NONE	
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REFERENCES CITED IN THE DESCRIPTION

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- *CHEMICAL ABSTRACTS,* 1 18-82-1 **[0056]**