



US 20210040407A1

(19) **United States**

(12) **Patent Application Publication**
DAUPHIN et al.

(10) **Pub. No.: US 2021/0040407 A1**

(43) **Pub. Date: Feb. 11, 2021**

(54) **HIGH-POWER AND ECO-FRIENDLY FUEL COMPOSITION**

(71) Applicant: **Total Marketing Services**, Puteaux (FR)

(72) Inventors: **Roland DAUPHIN**, Vienne (FR);
Jérôme OBIOLS, Feyzin (FR);
Thomas DUBOIS, Lyon (FR)

(73) Assignee: **Total Marketing Services**, Puteaux (FR)

(21) Appl. No.: **17/044,710**

(22) PCT Filed: **Apr. 19, 2019**

(86) PCT No.: **PCT/EP2019/060217**

§ 371 (c)(1),

(2) Date: **Oct. 1, 2020**

(30) **Foreign Application Priority Data**

Apr. 23, 2018 (FR) 1853534

Publication Classification

(51) **Int. Cl.**

C10L 10/10 (2006.01)

C10L 1/06 (2006.01)

(52) **U.S. Cl.**

CPC **C10L 10/10** (2013.01); **C10L 1/06**

(2013.01); **C10L 2290/24** (2013.01); **C10L**

2230/22 (2013.01); **C10L 2270/023** (2013.01);

C10L 2200/0423 (2013.01)

(57)

ABSTRACT

The present invention relates to a fuel composition comprising:—from 35% to 75% by weight of cyclopentane,—from 10% to 25% by weight of one or more aromatic hydrocarbon(s), and—up to 55% by weight of one or more branched alkane(s) chosen from 2-methylbutane and trimethylpentanes, with a weight ratio of the cyclopentane content to the aromatic hydrocarbon content greater than or equal to 2. The invention also relates to the use of such a composition for supplying a spark ignition engine, in particular for increasing the engine power and/or for reducing the specific fuel consumption of the engine and/or for increasing the octane number (RON).

HIGH-POWER AND ECO-FRIENDLY FUEL COMPOSITION

[0001] The present invention relates to a fuel composition intended for vehicles including a spark ignition engine (also known as gasoline engine), which has enhanced performance levels both in terms of engine power and energy savings.

[0002] The invention further relates to the use of such a composition in a spark ignition engine for increasing the power and/or reducing the specific fuel consumption.

PRIOR ART

[0003] Gasoline type fuels capable of being used in spark ignition engines, in particular those of motor vehicles, must have sufficiently high octane numbers to avoid knocking phenomena.

[0004] In a manner known per se, the octane number measures the resistance to self-ignition of a fuel used in a spark ignition engine.

[0005] Typically, the gasoline fuels marketed in Europe, compliant with standard EN 228, have a motor octane number (MON) greater than 85 and a research octane number (RON) of at least 95. These fuels are suited to the vast majority of motor vehicle engines.

[0006] In order to increase the efficiency thereof, modern spark ignition engines tend to operate with increasingly high volume compression ratios, i.e. with a high compression ratio applied on the fuel/air mixture in the engine before the ignition thereof.

[0007] However, increasing the volume compression ratio in an engine increases the risks of abnormal combustion of the knocking type, generated by local self-ignition of the air/fuel mixture upstream of the flame front. This phenomenon creates a characteristic noise and is capable of causing damage to the engine.

[0008] For very high-power engines, such as the engines of motor racing vehicles, a high volume compression ratio is particularly sought after.

[0009] It is thus essential that this type of engine is used with fuels having a high pre-ignition and knock resistance, and having research octane numbers (RON) as high as possible. If the octane numbers are insufficient relative to the volume compression ratio applied on the engine, the fuel self-ignition or knocking phenomenon may arise, which can significantly reduce the performance levels of the engine and cause significant damage thereto.

[0010] Moreover, for all vehicles and in particular those intended for general public applications, fuel compositions having so-called "fuel economy" properties (also referred to as "FE") are being increasingly sought after, i.e. fuels allowing the specific fuel consumption of the engine to be reduced, in order to procure energy savings and reduce CO2 emissions. However, this reduction in the specific fuel consumption must not occur at the expense of the engine power, which must be preserved or even increased.

[0011] There is thus a need to develop new fuel compositions intended to supply spark ignition engines which meet the requirements of modern vehicles, whether intended for racing or other applications, in particular domestic applications.

[0012] There is thus a need for fuels for spark ignition internal combustion engines that have a high octane number, and more particularly a high RON, and which maximise the

engine power of the motor vehicles operating with a high volume compression ratio, in particular motor racing vehicles.

[0013] One purpose of the present invention is thus to enhance the performance levels of gasoline fuel compositions, in particular of fuel compositions intended for motor racing vehicles, however without being limited thereto. The purpose is to increase the power of the spark ignition engine, whether it is of the naturally-aspirated or turbocharged type, during the combustion of the gasoline fuel composition in the engine.

[0014] There is also a need for "fuel economy" type fuels that reduce the specific fuel consumption of the engine, without reducing the power thereof.

[0015] In a manner that is well known in the prior art, additives improving the octane number (or octane boosters) are typically added to the fuel compositions. Organometallic compounds in particular comprising iron, lead or manganese are well-known octane boosters.

[0016] Tetraethyl lead (TEL) has been extensively used in this manner as a highly effective octane booster. However, in most regions of the world, TEL and other organometallic compounds can now only be used in fuels in very small amounts, if at all, since they can be toxic, cause damage to the engine and are harmful for the environment.

[0017] Non-metal-based octane boosters comprise oxygenated compounds (for example ethers and alcohols) and aromatic amines. However, these additives also suffer from various drawbacks. For example, N-methylaniline (NMA), an aromatic amine, must be used at a relatively high treat rate (1.5 to 2% by weight of additive/weight of base fuel) to have a significant effect on the octane number of the fuel. NMA can also be toxic. Oxygenates give a reduction in energy density in the fuel and, as with NMA, they have to be added at high treat rates, potentially causing compatibility problems with fuel storage, fuel lines, seals and other engine components.

[0018] For example, U.S. Pat. No. 4,812,146 describes unleaded gasoline fuel compositions for motor racing engines that comprise at least four components chosen from among butane, isopentane, le toluene, MTBE (methyl tert-butyl ether) and an alkylate.

[0019] International patent No. WO2010/014501 describes unleaded gasoline fuel compositions comprising at least 45 vol. % of branched paraffins, at most 34 vol. % of one or more mono- or di-alkylated benzenes, from 5 to 6 vol. % of at least one linear paraffin having 3 to 5 carbon atoms (written C3-C5), and one or more alkanols having 2 to 4 carbon atoms (written C2-C4), in an amount sufficient to boost the AKI (Anti-Knock Index) i.e. $(RON+MON)/2$ of at least 93. These compositions are presented as having a high torque output and maximum power.

[0020] Thus, fuel compositions having good intrinsic properties are sought after, i.e. fuel compositions that do not require the addition of octane boosters such as those described hereinabove.

[0021] U.S. patent No. US 2015/0259619 describes a fuel composition having a high octane number, in particular intended for aircraft engines, and which comprises 1 to 60% by weight of at least one alicyclic alkane, up to 60% by weight of at least one linear or branched alkane, and up to 50% by weight of aromatics.

[0022] U.S. Pat. No. 4,401,983 describes a high-octane fuel, also essentially intended for aircraft, comprising a

major proportion of a trimethylpentane fraction having a boiling point ranging from 105 to 115° C., and a minor proportion of an aromatic hydrocarbon fraction.

[0023] International patent No. WO 00/47697 describes fuel compositions allowing the engine to operate at lean burn limits, which results in fuel savings and reduced emissions, while meeting standard fuel specifications in particular as regards the octane number. These compositions contain specific compounds, in particular chosen from among oxygenated compounds of formula R1-O—R2, olefins, cycloalkanes or aromatic compounds.

SUBJECT-MATTER OF THE INVENTION

[0024] Continuing its research in the development of high-performance fuel formulations, the Applicant has now discovered a composition that meets the aforementioned objectives, and which has properties that are superior to those of the compositions of the prior art.

[0025] Thus, the present invention relates to a fuel composition comprising:

[0026] from 35% to 75% by weight of cyclopentane,

[0027] from 10% to 25% by weight of one or more aromatic hydrocarbons, and

[0028] up to 55% by weight of one or more branched alkanes chosen from 2-methylbutane and trimethylpentanes,

[0029] with a weight ratio of the amount of cyclopentane to the amount of aromatic hydrocarbon greater than or equal to 2.

[0030] These compositions are intended to supply spark ignition engines (or gasoline engines).

[0031] The fuel compositions according to the invention have particularly high research octane numbers (RON).

[0032] In uses in which the fuel flow rate is capped, in particular in the case of racing vehicles (for example in Formula 1), the use of the composition according to the invention allows higher engine power levels to be achieved for a constant fuel flow rate.

[0033] In particular, the incorporation, into the composition of the invention, of the three types of compounds (cyclopentane, aromatic hydrocarbons and branched alkanes) in the specific proportions defined hereinabove has been found to procure synergistic performance levels as regards the RON and the engine power.

[0034] The fuel composition according to the present invention also has an excellent net calorific value (NCV). In a manner known per se, the NCV of a gasoline composition can be measured in accordance with the method described in standard ASTM D 240, or be calculated from the chromatographic fingerprint of the composition.

[0035] The aforementioned properties are particularly sought after for use in racing vehicles.

[0036] The composition according to the invention also has significant advantages for uses other than in racing vehicles, such as for example so-called general public uses, since it allows the specific fuel consumption of the engine to be reduced. Again, the composition according to the invention procures synergistic results as regards reducing the fuel consumption of the engine. Thus, the composition according to the invention has excellent fuel economy type properties. It also reduces CO₂ emissions compared to a conventional gasoline composition.

[0037] The invention further relates to the use of the composition according to the invention for supplying a spark ignition engine.

[0038] According to one specific embodiment, the composition according to the invention is used as a fuel to supply a high-power and high-efficiency spark ignition engine, preferably an engine of a motor racing vehicle.

[0039] Other purposes, features, aspects and advantages of the invention will appear more clearly after reading the following description and examples.

[0040] In the description hereinbelow, and unless specified otherwise, the limits of a value domain are included in this domain, in particular in the expressions: “included between . . . and . . .”, “lying in the range . . . to . . .”, and “ranging from . . . to . . .”.

[0041] Moreover, the expressions “at least one” and “at least” used in the present description are respectively equivalent to the expressions “one or more” and “greater than or equal to”.

[0042] Finally, in a manner known per se, the term CN compound denotes a compound containing N carbon atoms in the chemical structure thereof.

DETAILED DESCRIPTION

[0043] The Fuel Composition

[0044] As stated hereinabove, the composition according to the invention contains cyclopentane, in an amount ranging from 35% to 75% by weight, relative to the total weight of the composition.

[0045] Preferably, the amount of cyclopentane ranges from 36 to 62% by weight relative to the total weight of the composition.

[0046] The composition according to the invention further contains one or more aromatic hydrocarbons, in an amount ranging from 10 to 25% by weight, relative to the total weight of the composition.

[0047] Preferably, the aromatic hydrocarbon amount ranges from 13 to 24% by weight, relative to the total weight of the composition.

[0048] The aromatic hydrocarbons are advantageously monocyclic. They are preferably chosen from among C₇ to C₁₀ hydrocarbons containing a benzene ring.

[0049] According to one preferred embodiment, the one or more aromatic hydrocarbons are chosen from those including, on the benzene ring: a single substituent; or two substituents in the meta or para position; or three substituents in the meta position.

[0050] The one or more aromatic hydrocarbons are more preferably chosen from among toluene, ethylbenzene, xylenes (and in particular 1,2-dimethylbenzene or ortho-xylene, 1,3-dimethylbenzene or meta-xylene and 1,4-dimethylbenzene or para-xylene, preferably meta-xylene and para-xylene), 1-ethyl-3-methylbenzene, mesitylene (1,3,5-trimethylbenzene), 1-ethyl-3,5-dimethylbenzene, and mixtures of these compounds.

[0051] Toluene, xylenes and mixtures of these compounds are particularly preferred.

[0052] Moreover, the composition according to the invention has a weight ratio of its cyclopentane amount to its aromatic hydrocarbon amount that is greater than or equal to 2. Preferably, this weight ratio lies in the range 2 to 7, more preferably in the range 2 to 6.5, and even more preferably in the range 2.5 to 4.

[0053] According to one particularly preferred embodiment, this weight ratio lies in the range 2.8 to 3.2 and more preferably in the range 3 to 3.2.

[0054] Finally, the composition according to the invention contains one or more branched alkanes chosen from among 2-methylbutane and trimethylpentanes, the amount whereof can reach up to 55% by weight, preferably up to 50% by weight, relative to the total weight of the composition. Preferably, this amount lies in the range 15 to 50% by weight, relative to the total weight of the composition.

[0055] Preferably, the one or more branched alkanes are chosen from among trimethylpentanes, and more preferably from among 2,2,4-trimethylpentane (or isooctane), 2,3,3-trimethylpentane, 2,3,4-trimethylpentane and mixtures thereof.

[0056] 2,2,4-trimethylpentane (isooctane) is particularly preferred.

[0057] The composition as described hereinabove has a research octane number (RON number) greater than or equal to 95, preferably greater than or equal to 100, and more preferably greater than or equal to 101, the RON being measured according to the standard ASTM D 2699-86.

[0058] The aforementioned values relate to the intrinsic octane number of the composition, that is to say without the addition of additional compounds, in particular such as octane boosting additives, for example those described above.

[0059] In addition to the base compounds described hereinabove, the fuel composition according to the invention can further comprise one or more additives, chosen from among those conventionally used in gasoline fuels.

[0060] In particular, the composition according to the invention can comprise at least one detergent additive ensuring the cleanliness of the intake circuit. Such an additive can for example be chosen from within the group consisting of succinimides, polyetheramines and quaternary ammonium salts, for example those described in the patent documents U.S. Pat. No. 4,171,959 and WO2006135881.

[0061] The composition can also comprise at least one lubricity additive or anti-wear agent, in particular (but in a non-limiting manner) chosen from within the group consisting of fatty acids and the ester or amide derivatives thereof, in particular glycerol monooleate, and derivatives of mono- and polycyclic carboxylic acids. Examples of such additives are given in the following patent documents: EP680506, EP860494, WO98/04656, EP915944, FR2772783 and FR2772784.

[0062] Other additives can also be incorporated into the fuel composition according to the invention, such as additives protecting against valve seat recession and anti-oxidant additives.

[0063] For use in a racing vehicle, in order to ensure maximum safety when refuelling, the electrical conductivity of the fuel is moreover preferably greater than 200 pS/m. For this purpose, at least one additive can be added to lower the electrical conductivity.

[0064] The additives described hereinabove can be added in amounts ranging, for each thereof, from 10 to 1,000 ppm by weight, preferably from 100 to 500 ppm by weight, to the fuel composition.

[0065] The fuel compositions according to the invention have a lead concentration that is generally less than or equal to 0.5 g/L (present for example in the form of tetraethyl

lead), and are preferably unleaded, i.e. they do not contain lead or any lead-containing compound.

[0066] The composition according to the invention can be prepared by simply mixing the constituents thereof.

[0067] One non-limiting example of a preparation method comprises the following steps of:

[0068] preparing a mixture A containing 75% by weight of cyclopentane and 25% by weight of one or more aromatic hydrocarbons as described hereinabove; then

[0069] adding the one or more branched alkanes to the mixture A, to a maximum concentration of 55% by weight of the final mixture.

[0070] This example provides a composition according to the invention that has a cyclopentane/aromatic hydrocarbon weight ratio of 3. It goes without saying that a person skilled in the art will know how to adapt this method to the preparation of other compositions in the formulation field of the invention.

[0071] Uses

[0072] The invention further relates to the use of the composition as described hereinabove to supply a spark ignition engine. The engine can be of the direct injection type or of the indirect injection type.

[0073] According to a first embodiment, the composition according to the invention is used to increase the power of the engine.

[0074] In this embodiment, the fuel composition can be advantageously used to supply a high-efficiency and high-power spark ignition engine, preferably an engine of a motor racing vehicle. It can in particular be a naturally-aspirated or turbocharged engine used in a racing vehicle (race track or rally vehicles).

[0075] According to a second embodiment, the composition according to the invention is used to reduce the specific fuel consumption of the engine.

[0076] In this embodiment, the use according to the invention is of the "fuel economy" type, i.e. the specific fuel consumption thereof is reduced.

[0077] This use also allows the amount of CO₂ emitted into the atmosphere to be reduced.

[0078] The invention further relates to the use of the composition as described hereinabove to increase the RON (also known as the research octane number) of a gasoline fuel composition.

[0079] The examples hereafter are solely intended to illustrate the invention, and must not be interpreted as limiting the scope thereof.

EXAMPLES

Example 1: Preparing a Composition According to the Invention

[0080] The composition C, according to the invention, was prepared from the following starting compounds A and B:

[0081] A: a mixture of 75.5% by weight of cyclopentane with 24.5% by weight of aromatic hydrocarbons formed by a mixture of toluene and xylenes, having the following detailed composition:

Composition of the mixture A	% by weight
cyclopentane	75.5
toluene	6.8
paraxylene	6.3
orthoxylyene	2.8
metaxylyene	6.6
ethylbenzene	2

[0082] B: isooctane (2,2,4-trimethylpentane).

[0083] The composition C was obtained by simply mixing 50% by weight of A with 50% by weight of B. The final composition thereof is as follows:

[0084] 37.75% by weight of cyclopentane,

[0085] 12.25% by weight of aromatic hydrocarbons,

[0086] 50% by weight of isooctane,

[0087] Cyclopentane amount/aromatic hydrocarbon amount weight ratio=3.1.

Example 2: Properties of the Fuel Composition C

[0088] The following parameters were measured for the composition C of the invention, as well as for each of the starting compounds A and B:

[0089] Octane number RON, according to the protocol described in the standard ASTM D 2699-86:

[0090] RON(A)=102.7

[0091] RON(B)=100

[0092] RON(C)=104.9

[0093] It is clear that:

$$\text{RON}(C) > \text{RON}(A),$$

$$\text{RON}(C) > \text{RON}(B), \text{ and}$$

$$\text{RON}(C) > (\text{RON}(A) + \text{RON}(B))/2$$

[0094] Specific power P, and specific fuel consumption SFC (the latter corresponding to the mass of fuel needed to produce 1 kW·h of useful energy output):

[0095] The measurements were carried out under the same conditions for the three compositions, at constant fuel flow rate, on the same single-cylinder spark ignition engine, with a cubic capacity 350 cm³ and provided with direct fuel injection.

[0096] Results obtained, in terms of specific power:

[0097] P(A)=13.6 kW

[0098] P(B)=12.9 kW

[0099] P(C)=13.9 kW

[0100] It is clear that:

$$P(C) > P(A),$$

$$P(C) > P(B), \text{ and}$$

$$P(C) > (P(A) + P(B))/2$$

[0101] Results obtained, in terms of specific fuel consumption:

[0102] SFC(A)=232.5 g/kW·h

[0103] SFC(B)=247.9 g/kW·h

[0104] SFC(C)=227.6 g/kW·h

[0105] It is clear that:

$$\text{SFC}(C) < \text{SFC}(A),$$

$$\text{SFC}(C) < \text{SFC}(B), \text{ and}$$

$$\text{SFC}(C) < (\text{SFC}(A) + \text{SFC}(B))/2$$

[0106] These results show that the composition C according to the invention procures synergistic results as regards both the octane number RON and the specific power and specific fuel consumption, relative to each of the starting components A and B.

[0107] These improved performance levels are the result of the particular combination of the compounds claimed in the specific proportions defined in the present application, as well as of the choice of the higher weight ratio of the cyclopentane amount to the aromatic hydrocarbon amount.

1. A fuel composition comprising
from 35% to 75% by weight of cyclopentane,
from 10% to 25% by weight of one or more aromatic hydrocarbons, and
up to 55% by weight of one or more branched alkanes chosen from 2-methylbutane and trimethylpentanes, with a weight ratio of the cyclopentane amount to the aromatic hydrocarbon amount greater than or equal to 2.

2. The fuel composition according to claim 1, characterised in that the cyclopentane amount ranges from 36 to 62% by weight relative to the total weight of the composition.

3. The fuel composition according to claim 1, characterised in that the one or more aromatic hydrocarbons are chosen from among C₇ to C₁₀ hydrocarbons containing a benzene ring.

4. The fuel composition according to claim 3, characterised in that the one or more aromatic hydrocarbons are chosen from those including, on the benzene ring: a single substituent; or two substituents in the meta or para position; or three substituents in the meta position.

5. The fuel composition according to claim 4, characterised in that the one or more aromatic hydrocarbons are chosen from among toluene, ethylbenzene, xylenes, 1-ethyl-3-methylbenzene, mesitylene (1,3,5-trimethylbenzene), 1-ethyl-3,5-dimethylbenzene, and mixtures of these compounds.

6. The fuel composition according to claim 1, characterised in that the aromatic hydrocarbon amount ranges from 13 to 24% by weight, relative to the total weight of the composition.

7. The fuel composition according to claim 1, characterised in that it has a weight ratio of its cyclopentane amount to its aromatic hydrocarbon amount that lies in the range of 2 to 7.

8. The fuel composition according to claim 1, characterised in that the one or more branched alkanes are chosen from among trimethylpentanes, 2,3,3-trimethylpentane, 2,3,4-trimethylpentane and mixtures thereof.

9. The fuel composition according to claim 1, characterised in that the branched alkane contained therein is 2,2,4-trimethylpentane (isooctane).

10. The fuel composition according to claim 1, characterised in that it contains said one or more branched alkanes in an amount of up to 50% by weight relative to the total weight of the composition.

11. Use of a composition as defined in claim 1 to increase the RON of a gasoline fuel composition.

12. The use of the fuel composition as defined in claim 1 to supply a spark ignition direct injection engine or an indirect injection engine.

13. The use according to claim 12 to increase the power of the engine.

14. The use according to claim 12 to reduce the specific fuel consumption of the engine.

15. The use according to claim 12, wherein the engine is a high-efficiency and high-power spark ignition engine, preferably an engine of a motor racing vehicle.

16. The fuel of claim 5, where the xylenes comprise 1,3-dimethylbenzene or meta-xylene and 1,4-dimethylbenzene or para-xylene.

17. The fuel of claim 5, characterised in that the one or more aromatic hydrocarbons are chosen from among toluene, xylenes and mixtures of these compounds.

18. The fuel composition of claim 7, where the weight ratio of its cyclopentane amount to its aromatic hydrocarbon amount lies in the range of 2 to 6.5.

19. The fuel composition of claim 7, where the weight ratio of its cyclopentane amount to its aromatic hydrocarbon amount lies in the range of 2.5 to 4.

20. The fuel composition according to claim 10, characterised in that it contains said one or more branched alkanes in an amount in the range of 15 to 50% by weight relative to the total weight of the composition.

* * * * *