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GASOLINE FUEL COMPOSITIONS

Field of the Invention

The present invention relates to a gasoline fuel composition, and in particular to the use of a certain wax-anti settling additive for increasing the level of
5 durene in the fuel composition.

Background of the Invention

The efforts to decarbonize the transport sector has increased research and investment in different technologies to produce renewable fuels from biological
10 and non-biological sources. Non-biological sources will have a significant importance in the future as renewable feedstock from biological origin will become more constrained due to its limited nature. Fuels produced from non-biological sources typically use hydrogen and
15 CO₂ to synthesise hydrocarbons. There are many commercially available processes that can produce Renewable Fuels of Non-Biological Origin (RFNBO) such as the Fischer-Tropsch synthesis and the Methanol-to-Gasoline (MTG) synthesis.

20 The Methanol-to-Gasoline (MTG) synthesis is widely recognised in the industry and it is known to produce a significant amount of Durene (1,2,4,5-tetramethylbenzene) as byproduct. The raw synthetic gasoline coming out of the Methanol-to-Gasoline synthesis normally contains a
25 higher concentration of durene than found in conventional gasoline from crude oil. Durene is an undesired product in the final gasoline product due to its high melting point (79.2°C). On temperature reduction, MTG comprising durene exhibits a distinct deterioration in the flow
30 properties. The cause of this is the formation of

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crystals due to the high melting point of durene. The occurrence of these crystals leads rapidly to clogging of fuel filters both in tanks and in motor vehicles. In conventional gasoline the level of durene is reduced during hydrotreatment of the heavy gasoline cut.

Because of these problems with durene, various studies suggest that durene content should be kept below 2 vol% and preferably below 1.5 vol% to avoid drivability issues due to the crystallisation of Durene in the fuel injection system (filter, injector, inlet valves, fuel lines, etc.).

Traditionally, the issue of high levels of durene in gasoline produced from the Methanol-to-Gasoline process has been mitigated from a process perspective either by separating the Durene from the final blend or by upgrading through hydrotreating or alternative techniques.

Despite the issues surrounding the crystallisation of durene, durene has the potential to increase the performance of final fuel blends as it has a high Research Octane Number (an estimated blend RON of 154) which is a property that influences the performance of gasoline engines due to its capability to withstand higher compression ratios. Hence, it would be desirable to provide a way to increase the content of durene in a gasoline fuel blend, especially wherein the gasoline base fuel has been obtained from a methanol-to-gasoline process, while avoiding the drivability issues caused by the high melting point of durene.

30 Summary of the Invention

According to the present invention there is provided a fuel composition comprising:

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(i) a gasoline base fuel comprising durene at a level of at least 1.5 wt%, by weight of the fuel composition; and
(ii) an ionic or non-ionic, oil-soluble polar organic, nitrogen-containing compound which is capable of acting
5 as a wax crystal growth inhibitor in the gasoline base fuel.

According to another aspect of the present invention there is provided a use of a wax crystal growth inhibitor in a gasoline fuel composition for the purpose of
10 increasing the content of durene in the gasoline fuel composition wherein the wax crystal growth inhibitor comprises an ionic or non-ionic, oil-soluble polar organic nitrogen-containing compound.

According to another aspect of the present invention there is provided a method of increasing the level of durene in a gasoline fuel composition wherein the method
15 comprises a step of adding to the gasoline fuel composition a wax crystal growth inhibitor comprising an ionic or non-ionic, oil-soluble polar organic nitrogen-
20 containing compound.

It has surprisingly been found by the present inventors that by including the specified wax crystal growth inhibitor, higher levels of durene can be achieved in the final fuel composition, hence providing
25 significant performance benefits (higher RON), as well as cost saving, energy saving, reduced CO₂ emissions, and process simplification opportunities as less processing steps are required to mitigate the drivability issues typically caused by the high melting point of durene.
30 Avoiding additional processing steps or reducing operating temperature could have an impact on the overall greenhouse gas footprint of the fuel composition.

Brief Description of the Drawings

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Figure 1 is graphical representation of the data set out in Table 1.

Figure 2 is a graph showing the relationship between the Cloud Point (°C) (y axis) and the amount (wt%) of durene (x axis) for the fuel blends tested in Example 2.

Detailed Description of the Invention

The gasoline fuel composition herein comprises a base fuel suitable for use in a spark ignition internal combustion engine wherein the gasoline base fuel comprises durene, and a wax anti-settling agent.

A first essential component in the fuel compositions herein is a wax anti-settling agent. The term 'wax anti-settling agent' can also be used interchangeably with the term 'wax crystal growth inhibitor'. The wax anti-settling agent is added to the gasoline fuel composition herein for the purpose of increasing the content of durene in the gasoline fuel composition. Increasing the content of durene serves to increase the RON number of the final fuel composition. Surprisingly, by including the specified wax anti-settling agent in the fuel composition of the present invention it has been found that the content of durene can be increased or maximized while reducing the undesirable effects of crystallization of the durene. The increase in durene content is compared to an analogous fuel composition comprising the same gasoline base fuel but which does not contain said wax anti-settling agent.

A suitable wax anti-settling agent comprises an ionic or non-ionic, oil-soluble polar organic, nitrogen-containing compound which is capable of acting as a wax crystal growth inhibitor in fuels. Suitable examples of such a wax anti-settling agent include one or more of the compounds (a) to (c) as follows:

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(a) An amine salt and/or amide formed by reacting at least one molar proportion of a hydrocarbyl substituted amine with a molar proportion of a hydrocarbyl acid having 1 to 4 carboxylic acid groups or its anhydride. Esters/amides may be used containing 30 to 300, preferably 50 to 150 total carbon atoms. Suitable amines are usually long chain C12-C40 primary, secondary, tertiary or quaternary amines or mixtures thereof, but shorter chain amines may be used provided the resulting nitrogen compound is oil soluble and therefore normally contains about 30 to 300 total carbon atoms. The nitrogen compound preferably contains at least one straight chain C8 to C40, preferably C14 to C24, alkyl segment.

Suitable amines include primary, secondary, tertiary or quaternary, but preferably are secondary. Tertiary and quaternary amines can only form amine salts. Examples of amines include tetradecyl amine, cocamine, and hydrogenated tallow amine. Examples of secondary amines include dioctadecyl amine and methyl-behenyl amine. Amine mixtures are also suitable such as those derived from natural materials. A preferred amine is a secondary hydrogenated tallow amine of the formula HNR_1R_2 wherein R1 and R2 are alkyl groups derived from hydrogenated tallow fat composed of approximately 4% C14, 31% C16, 59% C18.

Examples of suitable carboxylic acids and their anhydrides for preparing the nitrogen compounds include cyclohexane 1,2-dicarboxylic acid, cyclohexene 1,2-dicarboxylic acid, cyclopentane 1,2 dicarboxylic acid and

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naphthalene dicarboxylic acid, and 1,4-dicarboxylic acids including dialkyl spirobis lactone. Generally, these acids have about 5-13 carbon atoms in the cyclic moiety. Preferred acids useful in the present invention are

5 benzene dicarboxylic acids such as phthalic acid, isophthalic acid, and terephthalic acid. Phthalic acid and its anhydride is particularly preferred. The particularly preferred compound is the amide-amine salt formed by reacting 1 molar portion of phthalic anhydride

10 with 2 molar portions of dehydrogenated tallow amine. Another preferred compound is the diamide formed by dehydrating this amide-amine salt.

Other examples are long chain alkyl or alkylene

15 substituted dicarboxylic acid derivatives such as amine salts of monamides of substituted succinic acids, examples of which are known in the art and described in US-A-4,147,520, for example. Suitable amines may be those described above.

20 Other examples are condensates such as described in EP-A-327,423.

b) A chemical compound comprising or including a

25 cyclic ring system, the compound carrying at least two substituents of the general formula (I) below on the ring system



30 where A is an aliphatic hydrocarbyl group that is optionally interrupted by one or more hetero atoms and that is straight chain or branched, and R^1 and R^2 are the

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same or different and each is independently a hydrocarbyl group containing 9 to 40 carbon atoms optionally interrupted by one or more hetero atoms, the substituents being the same or different and the compound optionally
5 being in the form of a salt thereof. Preferably, A has from 1 to 20 carbon atoms and is preferably a methylene or polymethylene group.

As used herein, the term 'hydrocarbyl' refers to a group
10 having a carbon atom directly attached to the rest of the molecule and having a hydrocarbon or predominantly hydrocarbon character. Examples include hydrocarbon groups, including aliphatic (e.g. alkyl or alkenyl),
alicyclic (e.g. cycloalkyl or cycloalkenyl), aromatic,
15 and alicyclic-substituted aromatic, and aromatic-substituted aliphatic and alicyclic groups. Aliphatic groups are advantageously saturated. These groups may contain non-hydrocarbon substituents provided their presence does not alter the predominantly hydrocarbon
20 character of the group. Examples include keto, halo, hydroxy, nitro, cyano, alkoxy and acyl. If the hydrocarbyl group is substituted, a single (mono) substituent is preferred.

25 Examples of substituted hydrocarbyl groups include 2-hydroxyethyl, 3-hydroxypropyl, 4-hydroxybutyl, 2-ketopropyl, ethoxyethyl, and propoxypropyl. The groups may also or alternatively contain atoms other than carbon in a chain or ring otherwise composed of carbon atoms.
30 Suitable hetero atoms include, for example, nitrogen, sulphur, and, preferably, oxygen.

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- The cyclic ring system may include homocyclic, heterocyclic, or fused polycyclic assemblies, or a system where two or more such cyclic assemblies are joined to one another and in which the cyclic assemblies may be the same or different. Where there are two or more such cyclic assemblies, the substituents of the general formula (I) may be on the same or different assemblies, preferably on the same assembly. Preferably, the or each cyclic assembly is aromatic, more preferably a benzene ring. Most preferably, the cyclic ring system is a single benzene ring when it is preferred that the substituents are in the ortho or meta positions, which benzene ring may be optionally further substituted.
- The ring atoms in the cyclic assembly or assemblies are preferably carbon atoms but may for example include one or more ring N, S, or O atom, in which case or cases the compound is a heterocyclic compound.
- Examples of such polycyclic assemblies include:
- (i) Condensed benzene structures such as naphthalene, anthracene, phenanthrene, and pyrene;
 - (ii) Condensed ring structures where none of or not all of the rings are benzene such as azulene, indene, hydroindene, fluorene, and diphenylene oxide;
 - (iii) Rings joined 'end-on' such as diphenyl;
 - (iv) Heterocyclic compounds such as quinoline, indole, 2:3 dihydroindole, benzofuran, coumarin, isocoumarin, benzothiophen, carbazole and thiodiphenylamine;
 - (v) Non-aromatic or partially saturated ring systems such as decalin (i.e. decahydronaphthalene), alpha-pinene, cardinene, and bornylene; and

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(vi) Three-dimensional structures such as norbornene, bicycloheptane (i.e. norbornane), bicyclooctane, and bicyclooctene.

5 Each hydrocarbyl group constituting R1 and R2 in the invention (Formula I) may for example be an alkyl or alkylene group or a mono- or poly-alkoxylalkyl group. Preferably, each hydrocarbyl group is a straight-chain alkyl group. The number of carbon atoms in each
10 hydrocarbyl group is preferably 16 to 40, more preferably 16 to 24.

Also, it is preferred that the cyclic system is substituted with only two substituents of the general
15 formula (I) and that A is a methylene group.

Examples of salts of the chemical compounds are the acetate and the hydrochloride.

20 The compounds may conveniently be made by reducing the corresponding amide which may be made by reacting a secondary amine with the appropriate acid chloride; and

c) A condensate of long chain primary or secondary amine
25 with a carboxylic acid-containing polymer.

Specific examples include polymers such as described in GB-A-2,121,807, FR-A-2,592,387 and DE-A-3,941,561; and also esters of telemer acid and alkanolamines such as
30 described in US-A-4,639,256; a long chain epoxide/amine reaction product which may optionally be further reacted with a polycarboxylic acid; and the reaction product of an amine containing a branched carboxylic acid ester, an

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epoxide and a mono-carboxylic acid polyester such as described in US-A-4,631,071.

Further examples of suitable wax anti-settling agents for use herein include those compounds disclosed in WO93/18115 and WO2008/113757.

A preferred wax anti-settling agent for use herein is an unsaturated and conjugated carboxylic acid compound having the formula $\text{HOOC-CH=CH-C(X)=NR}$ wherein R is a C6 to C22 alkyl group and wherein X is a hydroxy group or an alkoxy group. Preferably, R is a C8 to C18 alkyl group, preferably a C12 to C18 alkyl group, especially a C13 alkyl group. Preferably the X group is hydroxy.

In an especially preferred embodiment, the wax anti-settling agent comprises 2-Butenoic, 4-oxo-4-(tridecylamino)-, (Z)-, branched (molecular formula: $\text{C}_{17}\text{H}_{31}\text{NO}_3$). Such a wax anti-settling agent is commercially available from BASF under the tradename Keroflux (RTM) 4990.

Durene has been found to be present at especially high levels in gasoline produced by an alcohol-to-gasoline process, such as a methanol-to-gasoline process. Durene is a highly symmetrical aromatic molecule and therefore the latent heat of crystallization is high, hence durene crystals form in gasoline formed in the methanol-to-gasoline process at higher temperatures than other less symmetrical aromatic molecules, such as pseudocumene or cumene. While not wishing to be limited by theory, it has been found that wax anti-settling additives (WASA) containing polar organic nitrogen-compounds such as those mentioned in (a), (b) and (c) above can be used to disrupt the durene crystallization

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process. In an especially preferred embodiment, the wax anti-settling agent comprises 2-Butenoic, 4-oxo-4-(tridecylamino)-, (Z)-, branched (molecular formula: C₁₇H₃₁NO₃). The conjugated molecular orbitals of the polar head of this molecule are able to interact with the π orbitals of durene, disrupt the crystallization process and change the morphology of any crystals that do form such that they are of the size that they are not observed by the eye or the DIN EN ISO 3015 test method for measuring Cloud Point. The uses and methods prevent the formation of crystals of durene until much lower temperatures are reached, compared with when a wax anti-settling agent is not present, hence avoiding the drivability issues due to the crystallization of durene in fuel injection systems (filter, injector, inlet valves, fuel lines, etc.) due to its high melting point. The crystallization temperature of the fuel composition is depressed compared with fuel compositions not containing said wax anti-settling agent.

The wax anti-settling agent is preferably present at a level from 0.01 wt% to 1 wt%, more preferably from 0.05 wt% to 0.5 wt%, even more preferably from 0.1 wt% to 0.3 wt%, based on the fuel composition.

The base fuel suitable for use in a spark ignition internal combustion engine is a gasoline base fuel, and therefore the fuel composition herein is a gasoline fuel composition.

In the liquid fuel compositions of the present invention, if the base fuel used is a gasoline, then the gasoline may be any gasoline suitable for use in an internal combustion engine of the spark-ignition (petrol) type known in the art, including automotive engines as well as in other types of engine such as, for example,

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off road and aviation engines. The gasoline used as the base fuel in the liquid fuel composition of the present invention may conveniently also be referred to as 'base gasoline'.

5 Gasolines typically comprise mixtures of hydrocarbons boiling in the range from 25 to 230 °C (EN-ISO 3405), the optimal ranges and distillation curves typically varying according to climate and season of the year. The hydrocarbons in a gasoline may be derived by
10 any means known in the art, conveniently the hydrocarbons may be derived in any known manner from straight-run gasoline, synthetically-produced aromatic hydrocarbon mixtures, thermally or catalytically cracked hydrocarbons, hydro-cracked petroleum fractions,
15 catalytically reformed hydrocarbons or mixtures of these.

The specific distillation curve, hydrocarbon composition, research octane number (RON) and motor octane number (MON) of the gasoline are not critical.

Conveniently, the research octane number (RON) of
20 the gasoline may be at least 80, for instance in the range of from 80 to 110, preferably the RON of the gasoline will be at least 90, for instance in the range of from 90 to 110, more preferably the RON of the gasoline will be at least 91, for instance in the range
25 of from 91 to 105, even more preferably the RON of the gasoline will be at least 92, for instance in the range of from 92 to 103, even more preferably the RON of the gasoline will be at least 93, for instance in the range of from 93 to 102, and most preferably the RON of the
30 gasoline will be at least 94, for instance in the range of from 94 to 100 (DIN EN ISO 5163) the motor octane number (MON) of the gasoline may conveniently be at least 70, for instance in the range of from 70 to 110,

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preferably the MON of the gasoline will be at least 75,
for instance in the range of from 75 to 105, more
preferably the MON of the gasoline will be at least 80,
for instance in the range of from 80 to 100, most
5 preferably the MON of the gasoline will be at least 82,
for instance in the range of from 82 to 95 (DIN EN ISO
5163).

Typically, gasolines comprise components selected
from one or more of the following groups; saturated
10 hydrocarbons, olefinic hydrocarbons, aromatic
hydrocarbons, and oxygenated hydrocarbons. Conveniently,
the gasoline may comprise a mixture of saturated
hydrocarbons, olefinic hydrocarbons, aromatic
hydrocarbons, and, optionally, oxygenated hydrocarbons.

15 Typically, the olefinic hydrocarbon content of the
gasoline is in the range of from 0 to 40 percent by
volume based on the gasoline (ASTM D1319); preferably,
the olefinic hydrocarbon content of the gasoline is in
the range of from 0 to 30 percent by volume based on the
20 gasoline, more preferably, the olefinic hydrocarbon
content of the gasoline is in the range of from 0 to 20
percent by volume based on the gasoline.

Typically, the aromatic hydrocarbon content of the
gasoline is in the range of from 0 to 70 percent by
25 volume based on the gasoline (ASTM D1319), for instance
the aromatic hydrocarbon content of the gasoline is in
the range of from 10 to 60 percent by volume based on the
gasoline; preferably, the aromatic hydrocarbon content of
the gasoline is in the range of from 0 to 50 percent by
30 volume based on the gasoline, for instance the aromatic
hydrocarbon content of the gasoline is in the range of
from 10 to 50 percent by volume based on the gasoline.

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The benzene content of the gasoline is at most 10 percent by volume, more preferably at most 5 percent by volume, especially at most 1 percent by volume based on the gasoline.

5 The gasoline preferably has a low or ultra low sulphur content, for instance at most 1000 ppmw (parts per million by weight), preferably no more than 500 ppmw, more preferably no more than 100, even more preferably no more than 50 and most preferably no more than even
10 10 ppmw.

The gasoline also preferably has a low total lead content, such as at most 0.005 g/l, most preferably being lead free - having no lead compounds added thereto (i.e. unleaded).

15 When the gasoline comprises oxygenated hydrocarbons, at least a portion of non-oxygenated hydrocarbons will be substituted for oxygenated hydrocarbons. The oxygen content of the gasoline may be up to 35 percent by weight (EN 1601) (e.g. ethanol per se) based on the gasoline.
20 For example, the oxygen content of the gasoline may be up to 25 percent by weight, preferably up to 10 percent by weight. Conveniently, the oxygenate concentration will have a minimum concentration selected from any one of 0, 0.2, 0.4, 0.6, 0.8, 1.0, and 1.2 percent by weight, and a
25 maximum concentration selected from any one of 5, 4.5, 4.0, 3.5, 3.0, and 2.7 percent by weight.

Examples of oxygenated hydrocarbons that may be incorporated into the gasoline include alcohols, ethers, esters, ketones, aldehydes, carboxylic acids and their
30 derivatives, and oxygen containing heterocyclic compounds. Preferably, the oxygenated hydrocarbons that may be incorporated into the gasoline are selected from alcohols (such as methanol, ethanol, propanol, 2-

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propanol, butanol, tert-butanol, iso-butanol and 2-butanol), ethers (preferably ethers containing 5 or more carbon atoms per molecule, e.g., methyl tert-butyl ether and ethyl tert-butyl ether) and esters (preferably esters
5 containing 5 or more carbon atoms per molecule); a particularly preferred oxygenated hydrocarbon is ethanol.

When oxygenated hydrocarbons are present in the gasoline, the amount of oxygenated hydrocarbons in the gasoline may vary over a wide range. For example,
10 gasolines comprising a major proportion of oxygenated hydrocarbons are currently commercially available in countries such as Brazil and U.S.A., e.g. ethanol per se and E85, as well as gasolines comprising a minor proportion of oxygenated hydrocarbons, e.g. E10 and E5.
15 Therefore, the gasoline may contain up to 100 percent by volume oxygenated hydrocarbons. E100 fuels as used in Brazil are also included herein. Preferably, the amount of oxygenated hydrocarbons present in the gasoline is selected from one of the following amounts: up to 85
20 percent by volume; up to 70 percent by volume; up to 65 percent by volume; up to 30 percent by volume; up to 20 percent by volume; up to 15 percent by volume; and, up to 10 percent by volume, depending upon the desired final formulation of the gasoline. Conveniently, the gasoline
25 may contain at least 0.5, 1.0 or 2.0 percent by volume oxygenated hydrocarbons.

Examples of suitable gasolines include gasolines which have an olefinic hydrocarbon content of from 0 to 20 percent by volume (ASTM D1319), an oxygen content of
30 from 0 to 5 percent by weight (EN 1601), an aromatic hydrocarbon content of from 0 to 50 percent by volume (ASTM D1319) and a benzene content of at most 1 percent by volume.

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In a preferred embodiment herein, the gasoline base fuel is obtained from an alcohol-to-gasoline process, e.g. ethanol-to-gasoline or methanol-to-gasoline. Typically, such alcohol-to-gasoline processes produce gasoline base fuels having relative high levels of durene.

Also suitable for use herein are gasoline blending components and gasoline base fuels which can be derived from a biological source. Examples of such gasoline blending components can be found in WO2009/077606, WO2010/028206, WO2010/000761, European patent application nos. 09160983.4, 09176879.6, 09180904.6, and US patent application serial no. 61/312307.

The gasoline base fuel is preferably present at a level from 50 vol% to 99 vol%, more preferably from 60 vol% to 95 vol%, even more preferably from 70 vol% to 90 vol%, based on the total fuel composition.

The gasoline base fuel used herein comprises a certain amount of durene of at least 1.5 wt%, based on the weight of the overall fuel composition. Preferably, the gasoline base fuel comprises 2.0 wt% or greater, more preferably from 2.5 wt% to 10 wt% of durene, based on the weight of the overall fuel composition. In preferred embodiments herein, the gasoline base fuel comprises 3.0 wt% or greater of durene, especially from 5 wt% to 10 wt% of durene, by weight of the total fuel composition.

Whilst not critical to the present invention, the base gasoline or the gasoline composition of the present invention may conveniently include one or more optional fuel additives, in addition to the essential amino-based deposit control additive and complex ester mentioned above. The concentration and nature of the optional fuel additive(s) that may be included in the base gasoline or

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the gasoline composition of the present invention is not critical. Non-limiting examples of suitable types of fuel additives that can be included in the base gasoline or the gasoline composition of the present invention include
5 anti-oxidants, corrosion inhibitors, deposit control additives/detergents other than the amino-based deposit control additive mentioned above, dehazers, antiknock additives, metal deactivators, valve-seat recession protectant compounds, dyes, solvents, carrier fluids,
10 diluents and markers. Examples of suitable such additives are described generally in US Patent No. 5,855,629.

Conveniently, the fuel additives can be blended with one or more solvents to form an additive concentrate, the additive concentrate can then be admixed with the base
15 gasoline or the gasoline composition of the present invention.

The (active matter) concentration of any optional additives present in the base gasoline or the gasoline composition of the present invention is preferably up to
20 1 percent by weight, more preferably in the range from 5 to 2000 ppmw, advantageously in the range of from 300 to 1500 ppmw, such as from 300 to 1000 ppmw.

As stated above, the gasoline composition may also contain synthetic or mineral carrier oils and/or
25 solvents.

In a preferred embodiment, the gasoline fuel composition has a RON of at least 92, preferably at least 95, and especially at least 98. As mentioned above, the wax anti-settling agent enables an increase in the amount
30 of durene in the fuel composition which serves to increase the RON number of the final fuel composition. Surprisingly, this is achieved while reducing the

deleterious effects caused by crystallisation of the durene.

In a preferred embodiment, the gasoline fuel composition meets the requirements of prevailing gasoline fuel specifications, such as the EN228 specification and the ASTM D4814 specification.

The present invention will be further understood from the following examples. Unless otherwise stated, all amounts and concentrations disclosed in the examples are based on weight of the fully formulated fuel composition.

Examples

Example 1

Various fuel blends were formulated by the addition of 2000ppmw various additives (MDFI/WASA) to a gasoline base fuel. The MDFI was Keroflux (RTM) 6170 commercially available from BASF and the WASA was Keroflux (RTM) 4990 commercially available from BASF. The gasoline base fuel used in the fuel blends of Example 1 was an EN228 E10 gasoline fuel (containing 10% ethanol). Various amounts of durene (2.5 wt%, 5.0 wt%, 7.5 wt%) were added to the formulations as set out in Table 1 below. In order to determine the effect of the additives on the crystallization properties of the durene, the cloud point of each of the fuel compositions was measured according to DIN EN ISO 3015. The results of these experiments are set out in Table 1.

Table 1

Fuel	Gasoline content (wt%)	Durene content (wt%)	Additive	Cloud Point (°C)
A*	97.5	2.5	None	-74.0
B*	97.5	2.5	MDFI	-74.3
C	97.5	2.5	WASA	-76.7

D*	95.0	5.0	No	-49.0
E*	95.0	5.0	MDFI	-55.5
F	95.0	5.0	WASA	No cloud**
G*	92.5	7.5	No	-39.4
H*	92.5	7.5	MDFI	-45.3
I	92.5	7.5	WASA	No cloud**

*Not according to the present invention

**No cloud signifies a cloud point of less than -120°C in this test

5 Figure 1 is a graphical representation of the Cloud Point data shown in Table 1.

Example 2

 Various fuel blends were formulated by the addition of 2000ppmw various additives (WASAs) to a gasoline base
10 fuel. The WASAs were Keroflux (RTM) 4990 commercially available from BASF, R728 commercially available from Infineum and OFI 5845 commercially available from Innospec. The gasoline base fuel used in the fuel blends of Example 2 was an EN228 E10 gasoline fuel (containing
15 10% ethanol). Various amounts of durene (2.5 wt%, 5.0 wt%, 7.5 wt%, 10 wt%) were added to the formulations. In order to determine the effect of the additives on the crystallization properties of the durene, the cloud point of each of the fuel compositions was measured according
20 to DIN EN ISO 3015. The results of these experiments can be seen in Table 2 and Figure 2.

Table 2

Fuel	Gasoline Content (w%)	Durene (w%)	Additive/ppm	Cloud Point (°C)
Base Fuel*	100.0%	0.0%	None	No cloud**
M*	97.5%	2.5%	None	-75.65

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N*	97.5%	2.5%	WASA 1 - Infineum R728 2000 ppm	-73.9
O	97.5%	2.5%	WASA 2- BASF KF4990 2000 ppm	-74
P*	97.5%	2.5%	WASA 3- Innospec OFI 5845 2000 ppm	-76.8
Q*	95.0%	5.0%	None	-48.7
R*	95.0%	5.0%	WASA 1 - Infineum R728 2000 ppm	-51.2
S	95.0%	5.0%	WASA 2- BASF KF4990 2000 ppm	No cloud**
T*	95.0%	5.0%	WASA 3- Innospec OFI 5845 2000 ppm	-45.9
U*	92.5%	7.5%	None	-37.4
V*	92.5%	7.5%	WASA 1 - Infineum R728 2000 ppm	-34.2
W	92.5%	7.5%	WASA 2- BASF KF4990 2000 ppm	No cloud**
X*	92.5%	7.5%	WASA 3- Innospec OFI 5845 2000 ppm	-33.8
Y*	90.0%	10.0%	None	-28
Z	90.0%	10.0%	WASA 2- BASF KF4990 2000 ppm	No cloud**

*Not according to the present invention

**No cloud signifies a cloud point of less than -120°C in this test

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Discussion

It can be seen from the experimental data in Tables 1 and 2 and Figures 1 and 2 that the only additive which showed good results in controlling the crystallization properties of the durene was the Keroflux (RTM) 4990 (Fuels C, F, I and Fuels O, S, W, Z).

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C L A I M S

1. A fuel composition comprising:

(i) a gasoline base fuel comprising durene at a level of at least 1.5 wt%, by weight of the fuel composition; and
(ii) an ionic or non-ionic, oil-soluble polar organic,
5 nitrogen-containing compound which is capable of acting as a wax crystal growth inhibitor in the gasoline base fuel.

2. A fuel composition according to Claim 1 wherein the
10 ionic or non-ionic, oil-soluble polar organic, nitrogen-containing compound is selected from one or more compounds (a) to (c) as follows:

(a) an amine salt and/or amide formed by reacting at least one molar proportion of a hydrocarbyl substituted
15 amine with a molar proportion of a hydrocarbyl acid having 1 to 4 carboxylic acid groups or its anhydride;

(b) a compound comprising or including a cyclic ring system, the compound carrying at least two substituents of the general formula (I) below on the ring system



where A is an aliphatic hydrocarbyl group that is optionally interrupted by one or more hetero atoms and that is straight chain or branched, and R¹ and R² are the same or different and each is independently a hydrocarbyl
25 group containing 9 to 40 carbon atoms optionally interrupted by one or more hetero atoms, the substituents being the same or different and the compound optionally being in the form of a salt thereof; and

(c) a condensate of long chain primary or secondary amine
30 with a carboxylic acid-containing polymer.

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3. A fuel composition according to Claim 1 or 2 wherein the ionic or non-ionic, oil-soluble polar organic, nitrogen-containing compound is an unsaturated and conjugated carboxylic acid compound having the formula
- 5 $\text{HOOC-CH=CH-C(X)=NR}$ wherein R is a C6-C22 alkyl group and wherein X is a hydroxy group or an alkoxy group.
4. A fuel composition according to Claim 3 wherein R is a C8-C18 alkyl group.
- 10 5. A fuel composition according to any of Claims 1 to 4 wherein the gasoline base fuel is obtained from an alcohol-to-gasoline process.
- 15 6. A fuel composition according to any of Claims 1 to 5 wherein the gasoline base fuel is obtained from a methanol-to-gasoline process.
- 20 7. A fuel composition according to any of Claims 1 to 4 wherein the gasoline base fuel is obtained from a dimethylether-to-gasoline process.
- 25 8. A fuel composition according to any of Claims 1 to 7 wherein the gasoline base fuel comprises 2.0 wt% or greater of durene, by weight of the fuel composition.
- 30 9. A fuel composition according to any of Claims 1 to 8 wherein the gasoline base fuel comprises from 2.5 wt% to 10 wt% of durene, by weight of the fuel composition.
10. A fuel composition according to any of Claims 1 to 9 wherein the gasoline base fuel comprises 3.0 wt% or greater of durene, by weight of the fuel composition.

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11. A fuel composition according to any of Claims 1 to 10 wherein the gasoline base fuel comprises from 5 wt% to 10 wt% of durene, by weight of the fuel composition.

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12. A fuel composition according to any of Claims 1 to 11 wherein the ionic or non-ionic, oil-soluble polar organic, nitrogen-containing compound is 2-butenic, 4-oxo-4-tridecylamino-, (Z)-, branched.

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13. A fuel composition according to any of Claims 1 to 11 wherein the ionic or non-ionic, oil-soluble polar organic, nitrogen-containing compound is present at a level from 0.01 wt% to 1 wt%, based on the fuel composition.

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14. A fuel composition according to any of Claims 1 to 13 wherein the fuel composition meets the EN228 Specification.

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15. Use of a wax crystal growth inhibitor in a gasoline fuel composition for the purpose of increasing the content of durene in the gasoline fuel composition wherein the wax crystal growth inhibitor comprises an ionic or non-ionic, oil-soluble polar organic nitrogen-containing compound.

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