SUMMARY

[0004] According to the present disclosure there is provided an unleaded gasoline fuel a fuel composition comprising a major amount of base fuel and a detergent additive package, wherein the detergent additive package comprises a quaternary ammonium internal salt detergent and a Mannich base detergent mixture, wherein the quaternary ammonium internal salt is obtained from amines or polyamines that is substantially devoid of any free anion species, and wherein the Mannich base detergent mixture comprises a first Mannich base detergent component derived from a di- or polyamine and a second Mannich base detergent component derived from a monoamine, wherein the weight ratio of the first Mannich base detergent to the second Mannich base detergent mixtures ranges from about 1:6 to about 3:1, and wherein the weight ratio of the quaternary ammonium internal salt detergent and the Mannich base detergent mixture ranges from about 1:10 to about 1:100.

[0004a] In a first aspect of the present disclosure, there is provided a gasoline fuel additive package comprising:

(i) a quaternary ammonium internal salt detergent and (ii) a Mannich base detergent mixture,

wherein the quaternary ammonium internal salt is obtained from amines or polyamines that is substantially devoid of any free anion species,

wherein the Mannich base detergent mixture comprises (a) a first Mannich base detergent component derived from a di- or polyamine and (b) a second Mannich base detergent component derived from a monoamine,

wherein the weight ratio of the first Mannich base detergent to the second Mannich base detergent mixture ranges from 1:6 to 3:1,

wherein the weight ratio of the quaternary ammonium internal salt detergent and the Mannich base detergent mixture ranges from 1:25 to 1:35.

[0005] According to the present disclosure there is further provided the use of an unleaded gasoline fuel composition for improving engine and/or injector performance in a gasoline direct injection engine, wherein the unleaded gasoline fuel composition comprises a major amount of gasoline base fuel and a detergent additive package, wherein the detergent

additive package comprises a quaternary ammonium internal salt detergent and a Mannich base detergent mixture, wherein the quaternary ammonium internal salt is obtained from amines or polyamines that is substantially devoid of any free anion species, and wherein the Mannich base detergent mixture comprises a first Mannich base detergent component derived from a di- or polyamine and a second Mannich base detergent component derived from a monoamine, wherein the weight ratio of the first Mannich base detergent to the second Mannich base detergent mixtures ranges from about 1:6 to about 3:1, and wherein the weight ratio of the quaternary ammonium internal salt detergent and the Mannich base detergent mixture ranges from about 1:10 to about 1:100.

[0006] According to the present disclosure there is further provided a method for improving engine performance and/or injector performance in a gasoline direct injection engine, the method comprising supplying to the engine an unleaded gasoline fuel composition comprising a major amount of gasoline base fuel and a detergent additive package wherein the detergent additive package comprises a quaternary ammonium internal salt detergent and a Mannich base detergent mixture, wherein the quaternary ammonium internal salt is obtained from amines or polyamines

that is substantially devoid of any free anion species, and wherein the Mannich base detergent mixture comprises a first Mannich base detergent component derived from a di- or polyamine and a second Mannich base detergent component derived from a monoamine, wherein the weight ratio of the first Mannich base detergent to the second Mannich base detergent mixtures ranges from about 1:6 to about 3:1, and wherein the weight ratio of the quaternary ammonium internal salt detergent and the Mannich base detergent mixture ranges from about 1:10 to about 1:100.

[0007] The method or the use of the previous paragraph may include optional steps, features, or limitations in any combination thereof. Approaches or examples of the method or use may include one or more of the following: wherein the improved injector performance is one of improved fuel flow, improved fuel economy, improved engine efficiency, or combinations thereof; and/or wherein the improved injector performance is measured by one of injector pulse width, injection duration, injector flow, or combinations thereof.

BRIEF DESCRIPTION OF DRAWINGS

[0008] FIG. 1 is a graph showing Long Term Fuel Trim (LTFT) of the Inventive example and Comparative examples 1 and 2.

DETAILED DESCRIPTION

[0009] The unleaded gasoline fuel composition of the present invention comprises combinations of Mannich detergents and quaternary ammonium salts and, in particular, Mannich detergents and hydrocarbyl-substituted quaternary ammonium internal salts discovered effective to provide improved engine and/or injector performance in gasoline direct injection (GDI) engines. Also provided herein are methods of using or combusting a fuel including the fuel additive combinations herein to achieve the improved engine and/or injector performance.

[00010] It has been found by the present inventors that the unleaded gasoline fuel composition of the present invention provides improved engine and/or injector performance, including controlling or reducing fuel injector deposits. Improved injector performance may also lead to one or more of improved fuel flow, improved fuel economy, and/or improved engine efficiency as determined via one or more of injector pulse width, injection duration, and/or injector flow.

[00011] In one aspect of the present invention, the unleaded gasoline fuel composition comprises a gasoline base fuel and a detergent additive package. The detergent additive package is typically used at a concentration from 6 PTB (23 ppmw) to 528 PTB (2000 ppmw), preferably

CLAIMS

WHAT IS CLAIMED IS:

1. A gasoline fuel additive package comprising:

(i) a quaternary ammonium internal salt detergent and (ii) a Mannich base detergent mixture,

wherein the quaternary ammonium internal salt is obtained from amines or polyamines that is substantially devoid of any free anion species,

wherein the Mannich base detergent mixture comprises (a) a first Mannich base detergent component derived from a di- or polyamine and (b) a second Mannich base detergent component derived from a monoamine,

wherein the weight ratio of the first Mannich base detergent to the second Mannich base detergent mixture ranges from 1:6 to 3:1,

wherein the weight ratio of the quaternary ammonium internal salt detergent and the Mannich base detergent mixture ranges from 1:25 to 1:35.

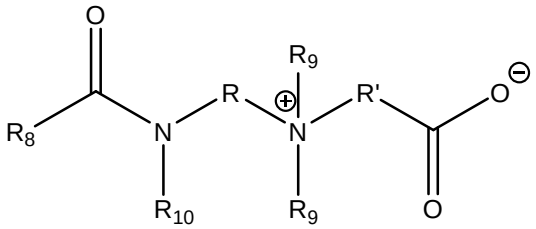
2. The gasoline fuel additive package according to claim 1, wherein the weight ratio of the first Mannich base detergent to the second Mannich base detergent ranges from 1:1 to 1:3.

3. The gasoline fuel additive package according to claim 1, wherein the first Mannich base detergent and the second Mannich base detergent are derived from polyisobutenyl-substituted hydroxyaromatic and wherein the polyisobutenyl group has a molecular weight ranging from 500 to 1000 Daltons, as determined by gel permeation chromatography.

4. The gasoline fuel additive package according to claim 3, wherein the polyisobutenyl-substituted hydroxyaromatic is polyisobutenyl-substituted phenol or cresol.

5. The gasoline fuel additive package according to claim 4, wherein the polyisobutenyl-substituted hydroxyaromatic is polyisobutenyl-substituted cresol.

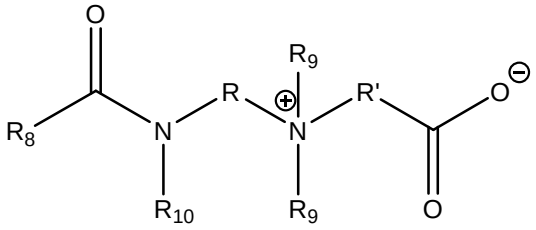
6. The gasoline fuel additive package according to claim 1, wherein the quaternary ammonium internal salt has the structure of Formula II



(Formula II)

wherein R and R' are, independently, alkylene linkers having 1 to 10 carbon atoms; R_8 is a C12 to C100 alkylene, alkene, or hydrocarbyl group or an aryl group or optionally substituted aryl group; each R_9 is, independently, a linear or branched C1 to C4 alkyl group; and R_{10} is a hydrogen atom or a C1 to C4 alkyl group.

7. The gasoline fuel additive package according to claim 5, wherein the quaternary ammonium internal salt has the structure of Formula II



(Formula II)

wherein R and R' are, independently, alkylene linkers having 1 to 10 carbon atoms; R_8 is a C12 to C100 alkylene, alkene, or hydrocarbyl group or an aryl group or optionally substituted aryl group; each R_9 is, independently, a linear or branched C1 to C4 alkyl group; and R_{10} is a hydrogen atom or a C1 to C4 alkyl group.

8. The gasoline fuel additive package according to claim 1, wherein the package further comprises a solvent, and the quaternary ammonium internal salt detergent (i) and the Mannich base detergent mixture (ii) constitutes 5-90% by weight of the package.

9. The gasoline fuel additive package according to claim 7, wherein the package further comprises a solvent, and the quaternary ammonium internal salt detergent (i) and the Mannich base detergent mixture (ii) constitutes 5-90% by weight of the package.

10. The gasoline fuel additive package according to claim 1, wherein the package further comprises one or more of a demulsifier, a corrosion inhibitor, an antiwear additive, an antioxidant, a metal deactivator, an antistatic additive, a dehazer, an antiknock additive, a lubricity additive, and a combustion improver.

11. The gasoline fuel additive package according to claim 7, wherein the package further comprises one or more of a demulsifier, a corrosion inhibitor, an antiwear additive, an antioxidant, a metal deactivator, an antistatic additive, a dehazer, an antiknock additive, a lubricity additive, and a combustion improver.

12. The gasoline fuel additive package according to claim 11, wherein the package further comprises a solvent, and the quaternary ammonium internal salt detergent (i) and the Mannich base detergent mixture (ii) constitutes 5-90% by weight of the package.

13. The gasoline fuel additive package according to claim 1, wherein the first Mannich base detergent component (a) is derived from N,N-dimethyl-1,3-propanediamine and the second Mannich base detergent component (b) is derived from dialkyl monoamine.

14. The gasoline fuel additive package according to claim 1, wherein the package further comprises a polyether monool or polyether polyol carrier fluid.

15. The gasoline fuel additive package according to claim 7, wherein the package further comprises a polyether monool or polyether polyol carrier fluid.

16. The gasoline fuel additive package according to claim 11, wherein the package further comprises a polyether monool or polyether polyol carrier fluid.

17. The gasoline fuel additive package according to claim 1, wherein the weight ratio of the quaternary ammonium internal salt detergent and the Mannich base detergent mixture ranges from 1:30 to 1:35.