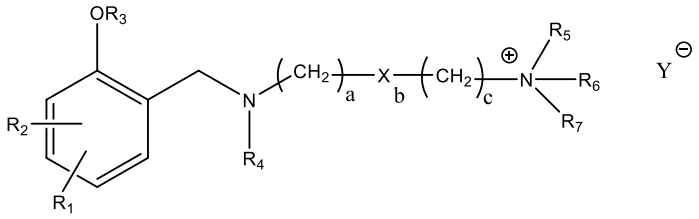
quaternized detergents are typically derived from PIBSI compounds that have pendant tertiary amine sites that can be alkylated, or quaternized, by hydrocarbyl epoxides, such as propylene oxide.

[0005] While providing improved detergency compared to prior detergents, these quaternary ammonium compounds and their methods of alkylation, however, still have several shortcomings. For instance, quaternary ammonium salts detergents often require the use of flammable and undesired epoxides, such as ethylene oxide propylene oxide, and/or require the use of specialized and expensive pressure vessels for their production. Such oxides, however, are often undesired due to their handling difficulties. In other instances, the alkoxylation step requires a carboxylic acid as proton donor. The resulting carboxylate may lead to deposit formation and other issues related to carboxylate salts being present in the additive and fuel. In other instances, the polyisobutenyl succinamide and/or ester intermediates tend to be viscous and/or difficult to handle during the manufacturing process. The reaction products often contain varying amounts of polyisobutenyl succinimides rendering it difficult to charge a correct amount of epoxide and/or acid to the reaction mixture. In other instances, quaternary ammonium compounds may be formed through alkylation using dialkyl carbonates. However, the carbonate anion may be susceptible to precipitation and drop out of certain types of fuels or fuel additive packages. Thus, prior quaternary ammonium compounds may have various shortcomings in their manufacture and/or application.

SUMMARY

[0006] As described herein is a quaternary ammonium salt fuel additive. In one approach or example, the quaternary ammonium salt fuel additive has the structure of Formula I

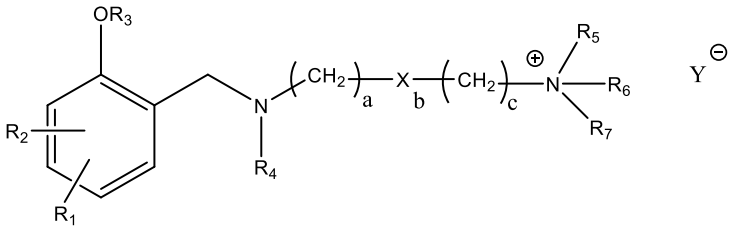


(Formula I)

wherein R_1 is a hydrocarbyl radical, wherein the number average molecular weight of the hydrocarbyl is about 200 to about 5,000; R_2 is hydrogen or a C_1-C_6 alkyl group; R_3 is

hydrogen or, together with R_4, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; R_4 is one of hydrogen, C_1-C_6 alkyl, –$(CH_2)_a$-NR_5R_6, –$(CH_2)_a$-Aryl(R_1)(R_2)(OR_3), or together with R_3, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; R_5 is C_1-C_6 alkyl or, together with $Y^{\ominus}$, forms a C1-C6 alkyl substituted –$C(O)O^{\ominus}$; R_6 and R_7, independently, are C_1-C_6 alkyl; a is an integer from 1 to 10, b is an integer selected from either 0 or 1, and c is an integer from 0 to 10; X is oxygen or nitrogen; and $Y^{\ominus}$ is an anionic group having a structure $R_8C(O)O^{\ominus}$ wherein R_8 is one of (i) together with R_5 a C_1-C_6 alkyl group or (ii) a C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

[0006a] In a first aspect of the present disclosure, there is provided a quaternary ammonium salt fuel additive comprising the structure of Formula I



(Formula I)

wherein

R_1 is a hydrocarbyl radical, wherein the number average molecular weight of the hydrocarbyl is 200 to 5,000;

R_2 is hydrogen or a C_1-C_6 alkyl group;

R_3 is hydrogen or, together with R_4, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_4 is one of hydrogen, C_1-C_6 alkyl, –$(CH_2)_a$-NR_5R_6, –$(CH_2)_a$-Aryl(R_1)(R_2)(OR_3), or together with R_3, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_5 is C_1-C_6 alkyl or, together with $Y^{\ominus}$, forms a C1-C6 alkyl substituted –$C(O)O^{\ominus}$;

R_6 and R_7, independently, are C_1-C_6 alkyl;

a is an integer from 1 to 10, b is an integer selected from either 0 or 1, and c is an integer from 0 to 10;

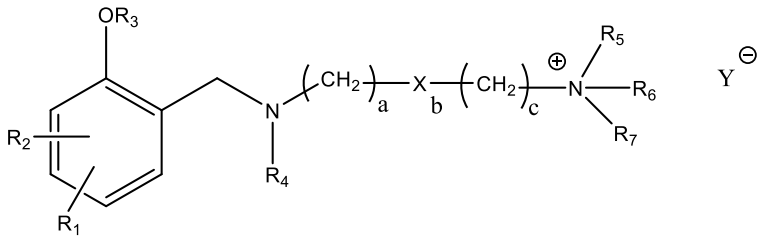
X is oxygen or nitrogen; and

$Y^{\ominus}$ is an anionic group having a structure $R_8C(O)O^{\ominus}$ wherein R_8 is one of (i) together with R_5 a C1-C6 alkyl group or (ii) a C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

[0007] In other approaches or examples, the additive of the previous paragraph may be combined with other features, examples, or approaches in any combination. Such examples may include one or more of: wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, and b and c are each 0; and/or wherein R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer; R_2 is hydrogen or a methyl group, the number average molecular weight being about 500 to about 1,500, R_3 together with R_4 is the –C(O)- group or the -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; a is an integer from 1 to 4, b and c are each 0; and/or wherein and R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen or a methyl group, R_3 is hydrogen, R_4 is the C_1-C_6 alkyl group, the –$(CH_2)_a$-NR_5R_6 group, or the –$(CH_2)_a$-Aryl$R_1R_2OR_3$ group, a is an integer from 1 to 4, b and c are each 0; and/or wherein and R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen

or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, b is 1, c is an integer from 1 to 4, and X is nitrogen or oxygen; and/or wherein and R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein the quaternary ammonium salt fuel additive is derived from (i) a Mannich reaction product or derivative thereof having at least one tertiary amino group and prepared from a hydrocarbyl-substituted phenol, cresol, or derivative thereof, an aldehyde, and a hydrocarbyl polyamine providing the tertiary amino group and reacted with (ii) a quaternizing agent selected from the group consisting of a carboxylic or polycarboxylic acid, ester, amide, or salt thereof or halogen substituted derivative thereof; and/or wherein the hydrocarbyl polyamine has the structure $R_9R_{10}N$-$[CH_2]_a$-X_b-$[CH_2]_c$-NR_9R_{10} wherein R_9 and R_{10} are independently a hydrogen or a C_1 to C_6 alkyl group with one R_9 and R_{10} pair forming a tertiary amine, X is oxygen or nitrogen, a is an integer from 1 to 10, b is an integer of 0 or 1, and c is an integer from 0 to 10; and/or wherein the quaternizing agent is a diester of a polycarboxylic acid; and/or wherein the quaternizing agent is a diester of oxalic acid, phthalic acid, maleic acid, or malonic acid, or combinations thereof; and/or wherein the quaternizing agent is a halogen substituted derivative of a carboxylic acid; and/or wherein the halogen substituted derivative of a carboxylic acid is a mono-, di-, or tri-chloro- bromo-, fluoro-, or iodo-carboxylic acid, ester, amide, or salt thereof selected from the group consisting of halogen-substituted acetic acid, propanoic acid, butanoic acid, isopropanoic acid, isobutanoic acid, *tert*-butanoic acid, pentanoic acid, heptanoic acid, octanoic acid, halo-methyl benzoic acid, and isomers, esters, amides, and salts thereof; and/or wherein the quaternary ammonium salt fuel additive is an internal salt substantially devoid of free anion species.

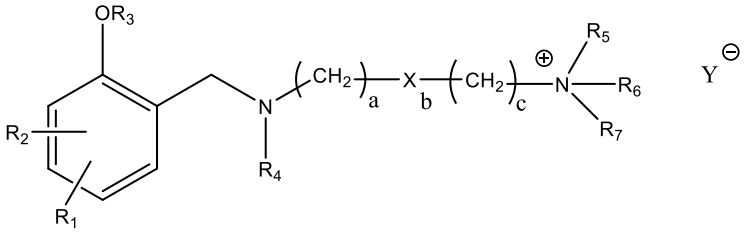
[0008] As described herein is a fuel composition comprising a major amount of fuel and a minor amount of a quaternary ammonium salt having the structure of Formula I. In examples, the structure of Formula is as follows:



(Formula I)

wherein R_1 is a hydrocarbyl radical, wherein the number average molecular weight of the hydrocarbyl is about 200 to about 5,000; R_2 is hydrogen or C_1-C_6 alkyl; R_3 is hydrogen or, together with R_4, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; R_4 is one of hydrogen, C_1-C_6 alkyl, –$(CH_2)_a$-NR_5R_6, –$(CH_2)_a$-Aryl$R_1R_2OR_3$, or together with R_3, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; R_5 is C_1-C_6 alkyl or, together with $Y^{\ominus}$, forms a C1-C6 alkyl substituted –$C(O)O^{\ominus}$; R_6 and R_7, independently, are C_1-C_6 alkyl; a is an integer from 1 to 10, b is an integer selected from either 0 or 1, and c is an integer from 0 to 10; X is oxygen or nitrogen; and $Y^{\ominus}$ is an anionic group having a structure $R_8C(O)O^{\ominus}$ wherein R_8 is one of (i) together with R_5 a C_1-C_6 alkyl group or (ii) a C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

[0008a] In another aspect of the present disclosure, there is provided a fuel composition comprising a major amount of fuel and a minor amount of a quaternary ammonium salt having the structure of Formula I



(Formula I)

wherein

R_1 is a hydrocarbyl radical, wherein the number average molecular weight of the hydrocarbyl is 200 to 5,000;

R_2 is hydrogen or C_1-C_6 alkyl;

R_3 is hydrogen or, together with R_4, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_4 is one of hydrogen, C_1-C_6 alkyl, –$(CH_2)_a$-NR_5R_6, –$(CH_2)_a$-Aryl$R_1R_2OR_3$, or together with R_3, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_5 is C_1-C_6 alkyl or, together with $Y^{\ominus}$, forms a C1-C6 alkyl substituted –$C(O)O^{\ominus}$;

R_6 and R_7, independently, are C_1-C_6 alkyl;

a is an integer from 1 to 10, b is an integer selected from either 0 or 1, and c is an integer from 0 to 10;

X is oxygen or nitrogen; and

$Y^{\ominus}$ is an anionic group having a structure $R_8C(O)O^{\ominus}$ wherein R_8 is one of (i) together with R_5 a C_1-C_6 alkyl group or (ii) a C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

[0009] In other approaches or examples, the fuel composition of the previous paragraph may be combined with other features, examples, or approaches in any combination. Such examples may include one or more of: wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, and b and c are each 0; and/or wherein R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen or a methyl group; R_3 together with R_4 is the –C(O)- group or the -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; a is an integer from 1 to 4, b and c are each 0; and/or wherein and R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen or a methyl group, R_3 is hydrogen, R_4 is the C_1-C_6 alkyl group, the –$(CH_2)_a$-NR_5R_6 group, or the –$(CH_2)_a$-Aryl$R_1R_2OR_3$ group, a is an integer from 1 to 4, b and c are each 0; and/or wherein and R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a

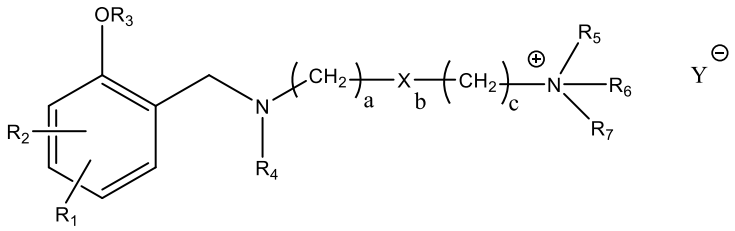
–C(O)O-R_2 group; and/or wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being about 500 to about 1,500, R_2 is hydrogen or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, b is 1, c is an integer from 1 to 4, and X is nitrogen or oxygen; and/or wherein and R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group; and/or wherein the fuel is selected from diesel or gasoline; and/or wherein the fuel is diesel and includes about 20 to about 200 ppm of the quaternary ammonium salt; and/or wherein the fuel is gasoline and includes about 5 to about 20 ppm of the quaternary ammonium salt; and/or wherein the quaternary ammonium salt is derived from (i) a Mannich reaction product or derivative thereof having at least one tertiary amino group and prepared from a hydrocarbyl-substituted phenol, cresol, or derivative thereof, an aldehyde, and a hydrocarbyl polyamine providing the tertiary amino group and reacted with (ii) a quaternizing agent selected from the group consisting of a carboxylic or polycarboxylic acid, ester, amide, or salt thereof or halogen substituted derivative thereof; and/or wherein the hydrocarbyl polyamine has the structure $R_9R_{10}N$-$[CH_2]_a$-X_b-$[CH_2]_c$-NR_9R_{10} wherein R_9 and R_{10} are independently a hydrogen or a C_1 to C_6 alkyl group with one R_9 and R_{10} pair forming a tertiary amine, X is oxygen or nitrogen, a is an integer from 1 to 10, b is an integer of 0 or 1, and c is an integer from 0 to 10; and/or wherein the quaternizing agent is a diester of a polycarboxylic acid; and/or wherein the quaternizing agent is a diester of oxalic acid, phthalic acid, maleic acid, or malonic acid, or combinations thereof; and/or wherein the quaternizing agent is a halogen substituted derivative of a carboxylic acid; and/or wherein the halogen substituted derivative of a carboxylic acid is a mono-, di-, or tri- chloro- bromo-, fluoro-, or iodo-carboxylic acid, ester, amide, or salt thereof selected from the group consisting of halogen-substituted acetic acid, propanoic acid, butanoic acid, isopropanoic acid, isobutanoic acid, *tert*-butanoic acid, pentanoic acid, heptanoic acid, octanoic acid, halo-methyl benzoic acid, and isomers, esters, amides, and salts thereof; and/or wherein the quaternary ammonium salt fuel additive is an internal salt substantially devoid of free anion species.

[00010] In yet further examples, the present disclosure provides the use of the fuel additive or the fuel composition of any example of this Summary to provide for improved engine performance, such as a power recovery of about 5 percent or great, about 10 percent or greater or about 40 percent or greater as measured by a CED F-98-08 test modified.

CLAIMS

WHAT IS CLAIMED IS:

1. A quaternary ammonium salt fuel additive comprising the structure of Formula I



(Formula I)

wherein

R_1 is a hydrocarbyl radical, wherein the number average molecular weight of the hydrocarbyl is 200 to 5,000;

R_2 is hydrogen or a C_1-C_6 alkyl group;

R_3 is hydrogen or, together with R_4, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_4 is one of hydrogen, C_1-C_6 alkyl, $–(CH_2)_a$-NR_5R_6, $–(CH_2)_a$-Aryl(R_1)(R_2)(OR_3), or together with R_3, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_5 is C_1-C_6 alkyl or, together with $Y^{\ominus}$, forms a C1-C6 alkyl substituted $–C(O)O^{\ominus}$;

R_6 and R_7, independently, are C_1-C_6 alkyl;

a is an integer from 1 to 10, b is an integer selected from either 0 or 1, and c is an integer from 0 to 10;

X is oxygen or nitrogen; and

$Y^{\ominus}$ is an anionic group having a structure $R_8C(O)O^{\ominus}$ wherein R_8 is one of (i) together with R_5 a C1-C6 alkyl group or (ii) a C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

2. The quaternary ammonium salt fuel additive of claim 1, wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being 500 to 1,500, R_2 is hydrogen or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, and b and c are each 0; and/or wherein R_5, R_6, and R_7 are

each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

3. The quaternary ammonium salt fuel additive of claim 1, wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer; R_2 is hydrogen or a methyl group, the number average molecular weight being 500 to 1,500, R_3 together with R_4 is the –C(O)- group or the -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring; a is an integer from 1 to 4, b and c are each 0; and/or wherein R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

4. The quaternary ammonium salt fuel additive of claim 1, wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being 500 to 1,500, R_2 is hydrogen or a methyl group, R_3 is hydrogen, R_4 is the C_1-C_6 alkyl group, the –$(CH_2)_a$-NR_5R_6 group, or the –$(CH_2)_a$-Aryl$R_1R_2OR_3$ group, a is an integer from 1 to 4, b and c are each 0; and/or wherein R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

5. The quaternary ammonium salt fuel additive of claim 1, wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being 500 to 1,500, R_2 is hydrogen or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, b is 1, c is an integer from 1 to 4, and X is nitrogen or oxygen; and/or wherein R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$ is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

6. The quaternary ammonium salt fuel additive of claim 1, wherein the quaternary ammonium salt fuel additive is derived from (i) a Mannich reaction product or derivative thereof having at least one tertiary amino group and prepared from a hydrocarbyl-substituted phenol, cresol, or derivative thereof, an aldehyde, and a hydrocarbyl polyamine providing the tertiary

amino group and reacted with (ii) a quaternizing agent selected from the group consisting of a carboxylic or polycarboxylic acid, ester, amide, or salt thereof or halogen substituted derivative thereof.

7. The quaternary ammonium salt fuel additive of claim 6, wherein the hydrocarbyl polyamine has the structure $R_9R_{10}N\text{-}[CH_2]_a\text{-}X_b\text{-}[CH_2]_c\text{-}NR_9R_{10}$ wherein R_9 and R_{10} are independently a hydrogen or a C_1 to C_6 alkyl group with one R_9 and R_{10} pair forming a tertiary amine, X is oxygen or nitrogen, a is an integer from 1 to 10, b is an integer of 0 or 1, and c is an integer from 0 to 10.

8. The quaternary ammonium salt fuel additive of claim 6, wherein the quaternizing agent is a diester of a polycarboxylic acid.

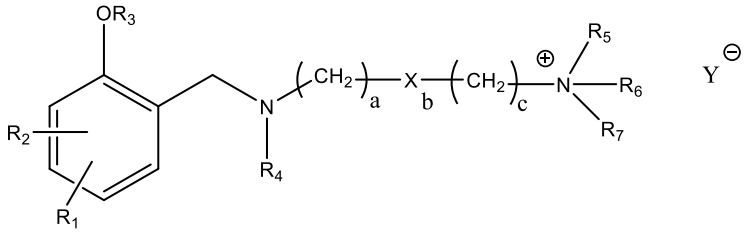
9. The quaternary ammonium salt fuel additive of claim 8, wherein the quaternizing agent is a diester of oxalic acid, phthalic acid, maleic acid, or malonic acid, or combinations thereof.

10. The quaternary ammonium salt fuel additive of claim 6, wherein the quaternizing agent is a halogen substituted derivative of a carboxylic acid.

11. The quaternary ammonium salt fuel additive of claim 10, wherein the halogen substituted derivative of a carboxylic acid is a mono-, di-, or tri- chloro- bromo-, fluoro-, or iodo-carboxylic acid, ester, amide, or salt thereof selected from the group consisting of halogen-substituted acetic acid, propanoic acid, butanoic acid, isopropanoic acid, isobutanoic acid, *tert*-butanoic acid, pentanoic acid, heptanoic acid, octanoic acid, halo-methyl benzoic acid, and isomers, esters, amides, and salts thereof.

12. The quaternary ammonium salt fuel additive of claim 11, wherein the quaternary ammonium salt fuel additive is an internal salt substantially devoid of free anion species.

13. A fuel composition comprising a major amount of fuel and a minor amount of a quaternary ammonium salt having the structure of Formula I



(Formula I)

wherein

R_1 is a hydrocarbyl radical, wherein the number average molecular weight of the hydrocarbyl is 200 to 5,000;

R_2 is hydrogen or C_1-C_6 alkyl;

R_3 is hydrogen or, together with R_4, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_4 is one of hydrogen, C_1-C_6 alkyl, –$(CH_2)_a$-NR_5R_6, –$(CH_2)_a$-Aryl$R_1R_2OR_3$, or together with R_3, a -C(O)- group or a -CH_2- group forming a ring structure with the nitrogen atom closest to the aromatic ring;

R_5 is C_1-C_6 alkyl or, together with $Y^{\ominus}$, forms a C1-C6 alkyl substituted –$C(O)O^{\ominus}$;

R_6 and R_7, independently, are C_1-C_6 alkyl;

a is an integer from 1 to 10, b is an integer selected from either 0 or 1, and c is an integer from 0 to 10;

X is oxygen or nitrogen; and

$Y^{\ominus}$ is an anionic group having a structure $R_8C(O)O^{\ominus}$ wherein R_8 is one of (i) together with R_5 a C_1-C_6 alkyl group or (ii) a C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-C(O)O-R_2 or a –C(O)O-R_2 group.

14. The fuel composition of claim 13, wherein R_1 is a hydrocarbyl radical derived from a polyisobutylene polymer or oligomer, the number average molecular weight being 500 to 1,500, R_2 is hydrogen or a methyl group, R_3 and R_4 are each hydrogen; a is an integer from 1 to 4, and b and c are each 0; and/or wherein R_5, R_6, and R_7 are each C_1-C_6 alkyl and wherein $Y^{\ominus}$

is the anionic group having the structure $R_8C(O)O^{\ominus}$ with R_8 being the C_1-C_6 alkyl, an aryl, a C_1-C_4 alklylene-$C(O)O$-R_2 or a $–C(O)O$-R_2 group.

15. The fuel composition of claim 13, wherein the fuel is diesel and includes 20 to 200 ppm of the quaternary ammonium salt or wherein the fuel is gasoline and includes 5 to 20 ppm of the quaternary ammonium salt.