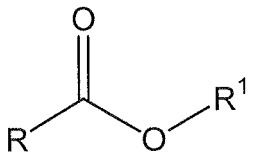
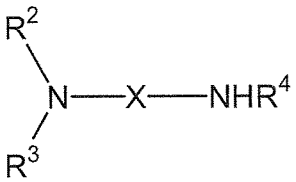
Claims:

1. A diesel fuel composition comprising a first additive (i) comprising a quaternary ammonium salt and a second additive (ii) comprising a Mannich reaction product; wherein the quaternary ammonium salt additive (i) is formed by the reaction of a compound of formula (A):

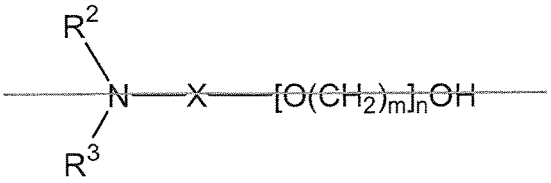


(A)

and a compound formed by the reaction of a hydrocarbyl-substituted succinic acid acylating agent and an amine of formula (B1) ~~or (B2)~~:



(B1)



~~(B2)~~

selected from N,N-dimethyl-1,3-diaminopropane, N,N-diethyl-1,3-diaminopropane, N,N-dimethylethylenediamine, N,N-diethylethylenediamine, N,N-dibutylethylenediamine, or combinations thereof;

~~wherein R is an optionally substituted alkyl, alkenyl, aryl or alkylaryl group; R^1 is a C_4 to C_{22} alkyl, aryl or alkylaryl group; wherein R^2 and R^3 are the same or different alkyl, alkenyl or aryl groups having from 1 to 22 carbon atoms; X is a bond or alkylene group having from 1 to 20 carbon atoms; n is from 0 to 20; m is from 1 to 5; and R^4 is hydrogen or a C_1 to C_{22} alkyl group; and wherein the Mannich reaction product additive (ii) is the product of a Mannich reaction between:~~

~~(a) an aldehyde;~~

~~(b) an amine; and~~

~~(c) a substituted phenol;~~

~~wherein the phenol is substituted with at least one branched hydrocarbyl group having a molecular weight of between 200 and 3000.~~

wherein compound (A) is selected from an ester of a carboxylic acid selected from one or more of oxalic acid, phthalic acid, salicylic acid, maleic acid, malonic acid, citric acid, nitrobenzoic acid, aminobenzoic acid and 2, 4, 6-trihydroxybenzoic acid; and

wherein the Mannich reaction product additive (ii) is the product of a Mannich reaction between:

(a) formaldehyde;

(b) a (poly)ethylene polyamine; and

(c) a polyisobutylene-substituted phenol; wherein the polyisobutenyl substituent has a molecular weight of between 300 and 2000.

2. A diesel fuel composition according to claim 1 wherein the compound of formula (A) is an ester of a carboxylic acid selected from a substituted aromatic carboxylic acid, an α-hydroxycarboxylic acid and a polycarboxylic acid.

3. A diesel fuel composition according to claim 2 wherein the compound of formula (A) is selected from dimethyl oxalate, methyl 2-nitrobenzoate and methyl salicylate.

~~4. A diesel fuel composition according to any preceding claim wherein the hydrocarbyl substituted acylating agent is reacted with a diamine compound of formula (B1).~~

~~5~~4. A diesel fuel composition according to any preceding claim wherein additive (i) is a salt of tertiary amine prepared from dimethylaminopropylamine and a polyisobutylene-substituted succinic anhydride.

~~6. A diesel fuel composition according to any preceding claim wherein component (a) used to prepare additive (ii) is formaldehyde~~.

~~7. A diesel fuel composition according to any preceding claim wherein component (b) used to prepare additive (ii) is a (poly)ethylene polyamine.~~

~~8. A diesel fuel composition according to any preceding claim wherein component (c) used to prepare additive (ii) is a polyisobutylene-substituted phenol.~~

~~9~~5. A diesel fuel composition according to any preceding claim wherein in the Mannich reaction used to form additive (ii) the molar ratio of component (a) to component (b) is 2.2-1.01:1; the molar ratio of component (a) to component (c) is 1.99-1.01:1 and the molar ratio of component (b) to component (c) is 1:1.01-1.99.

~~10~~6. A diesel fuel composition according to claim ~~9~~ 5, wherein in the reaction used to make the Mannich additive the molar ratio of component (a) to component (b) is 2-1.4:1, the molar ratio of component (a) to component (c) is 1.7-1.1:1 and the molar ratio of component (b) to component (c) is 1:1.1-1.7.

~~11~~7. A diesel fuel composition according to any preceding claim wherein the diesel fuel comprises a Fischer Tropsch fuel and/or biodiesel.

~~12~~8. A diesel fuel composition as claimed in any preceding claim which further comprises a fuel-borne catalyst which includes a metal selected from iron, cerium, group I and group II metals, platinum, manganese and mixtures thereof.

~~13~~9. An additive package which upon addition to a diesel fuel provides a composition as claimed in any preceding claim.

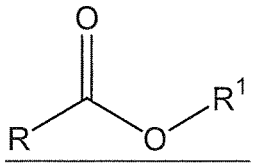
~~14~~10. A method of operating a diesel engine, the method comprising combusting in the engine a composition as claimed in any of claims 1 to ~~8~~12.

~~15~~11. Use of a quaternary ammonium salt additive (i) and a Mannich reaction product additive (ii) in a diesel fuel composition to improve the engine performance of a diesel engine when using said diesel fuel composition.

~~16~~12. The use according to claim ~~15~~ 11 to provide "keep clean" performance and/or "clean up" performance.

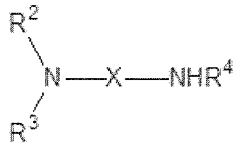
~~17~~13. A use according to claim ~~15~~ 11 or claim ~~16~~ 12 to improve the performance of a modern diesel engine having a high pressure fuel system and/or to improve the performance of a traditional diesel engine.

14. The use according to any one of claims 11 to 13, wherein the quaternary ammonium salt additive (i) is formed by the reaction of a compound of formula (A):



(A)

and a compound formed by the reaction of a hydrocarbyl-substituted succinic acid acylating agent and an amine of formula (B1)



(B1)

selected from N,N-dimethyl-1,3-diaminopropane, N,N-diethyl-1,3-diaminopropane, N,N-dimethylethylenediamine, N,N-diethylethylenediamine, N,N-dibutylethylenediamine, or combinations thereof; wherein compound (A) is selected from an ester of a carboxylic acid selected from one or more of oxalic acid, phthalic acid, salicylic acid, maleic acid, malonic acid, citric acid, nitrobenzoic acid, aminobenzoic acid and 2, 4, 6-trihydroxybenzoic acid; and wherein the Mannich reaction product additive (ii) is the product of a Mannich reaction between:

(a) formaldehyde

(b) a (poly)ethylene polyamine; and

(c) a polyisobutylene-substituted phenol; wherein the polyisobutenyl substituent has a molecular weight of between 300 and 2000.