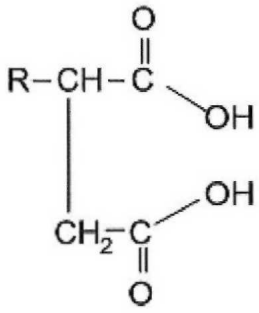
certain common corrosion inhibitors, biofuel components and acidic friction modifiers, or other carboxylic components used in the fuel interacting with trace amounts of alkali metal salts that form salts that are relatively insoluble in ultra low sulfur diesel (ULSD) fuels compared to the better solubility of such salts in the higher sulfur fuels. The internal deposits may be composed mainly of sodium salts of alkenyl succinic acids. Sodium can enter the diesel fuel from a number of sources including refinery salt drivers, storage tank water bottoms and seawater used as ship ballast. When such salts are present in fuel that is used in a High Pressure Common Rail (HPCR) engines, the salts may tend to deposit in the very tight tolerance areas of the injectors. Such deposits may lead to stuck fuel injectors or poor fuel injection, which in turn may lead to lost power, lost fuel economy, rough running engines, and eventually excessive vehicle downtime and maintenance expense. Many conventional detergents such as succinimide detergents, Mannich detergents and quaternary ammonium salt detergents are not particularly effective at conventional treat rates for removing alkali metal salt deposits from internal components of fuel injectors. Furthermore, the use of such detergents at excessively high treat rates may be detrimental to engine components. Accordingly, there is a continuing need for detergents that are effective for removing internal deposits without detrimentally affecting other engine components.

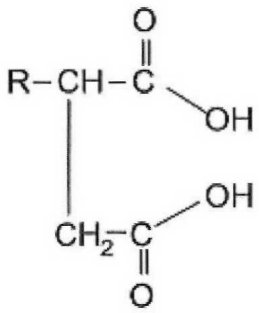
[0004a] In one aspect of the present disclosure, there is provided a method of improving the injector performance of a fuel injected diesel engine comprising operating the diesel engine on a fuel composition comprising (1) a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from 45 to 550 ppm by weight based on a total weight of fuel composition of a fuel additive consisting essentially of a compound of the formula



wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms, wherein the additive has a total acid number (TAN) ranging from 50 to 290 mg KOH/g, and wherein fuel injectors of the fuel injected diesel engine have an average injector hole

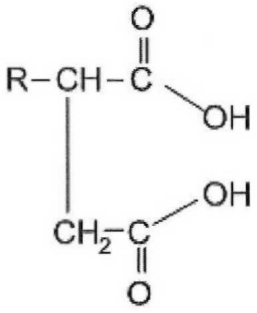
diameter of less than 160 μm and an average smallest clearance between injector needle and injector barrel/casing of less than 10 μm.

[0004b] In another aspect of the present disclosure, there is provided a method of unsticking fuel injectors of a fuel injected diesel engine and recovering lost engine power due to the presence of internal injector deposits comprising operating the diesel engine on a fuel composition comprising (1) a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from 45 to 550 ppm by weight based on a total weight of fuel composition of a fuel additive consisting essentially of a compound of the formula



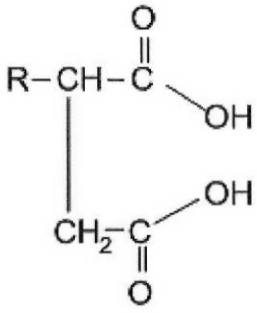
wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms and wherein the additive has a total acid number (TAN) ranging from 50 to 290 mg KOH/g, and wherein fuel injectors of the fuel injected diesel engine have an average injector hole diameter of less than 160 μm and an average smallest clearance between injector needle and injector barrel/casing of less than 10 μm, wherein the fuel injectors are not stuck after clean up, and wherein at least 20% of lost power is recovered in 8 hours according to a DW10 test using a sodium salt as a dopant.

[0004c] In yet another aspect of the present disclosure, there is provided a method for reducing an amount of alkali metal salt deposits on internal components of a fuel injector for a fuel injected diesel engine comprising operating the diesel engine on a fuel composition comprising (1) a major amount of fuel containing from 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from 45 to 550 ppm by weight based on a total weight of fuel composition of a fuel additive consisting essentially of a compound of the formula



wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms and wherein the additive has a total acid number (TAN) ranging from 50 to 290 mg KOH/g, and wherein fuel injectors of the fuel injected diesel engine have an average injector hole diameter of less than 160 μm and an average smallest clearance between injector needle and injector barrel/casing of less than 10 μm.

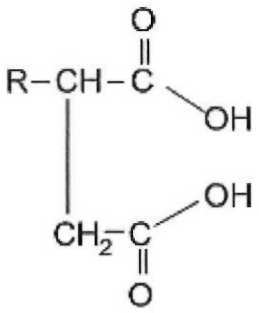
[0005] In accordance with the disclosure, exemplary embodiments provide a method for cleaning up internal components of a fuel injector and for improving injector performance for a diesel engine. The method includes operating the diesel engine on a fuel composition containing (1) a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from about 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from about 45 to about 550 ppm by weight based on a total weight of fuel composition of a fuel additive compound of the formula



wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms. The additive has a total acid number (TAN) ranging from about 50 to about 290 mg KOH/g. The fuel

WHAT IS CLAIMED IS:

1. A method of improving the injector performance of a fuel injected diesel engine comprising operating the diesel engine on a fuel composition comprising (1) a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from 45 to 550 ppm by weight based on a total weight of fuel composition of a fuel additive consisting essentially of a compound of the formula



wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms, wherein the additive has a total acid number (TAN) ranging from 50 to 290 mg KOH/g, and wherein fuel injectors of the fuel injected diesel engine have an average injector hole diameter of less than 160 μm and an average smallest clearance between injector needle and injector barrel/casing of less than 10 μm.

2. The method of claim 1, wherein R contains from 30 to 70 carbon atoms.

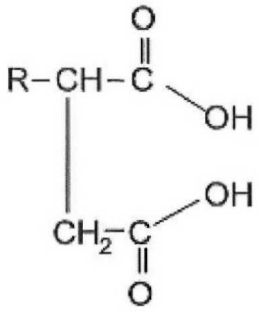
3. The method of claim 1, wherein the fuel additive comprises less than 10 ppm by weight of basic nitrogen from a nitrogen-containing compound.

4. The method of claim 1, wherein injector performance is improved by removing alkali metal carboxylate internal injector deposits.

5. The method of claim 1, wherein the fuel injected diesel engine comprises a direct fuel injected diesel engine.

6. The method of claim 1, wherein the additive has a TAN ranging from 100 to 250 mg KOH/g.

7. A method of unsticking fuel injectors of a fuel injected diesel engine and recovering lost engine power due to the presence of internal injector deposits comprising operating the diesel engine on a fuel composition comprising (1) a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from 45 to 550 ppm by weight based on a total weight of fuel composition of a fuel additive consisting essentially of a compound of the formula



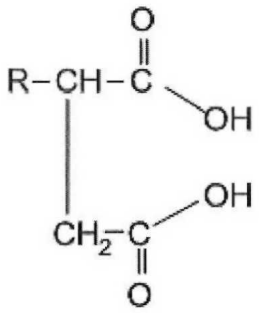
wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms and wherein the additive has a total acid number (TAN) ranging from 50 to 290 mg KOH/g, and wherein fuel injectors of the fuel injected diesel engine have an average injector hole diameter of less than 160 μm and an average smallest clearance between injector needle and injector barrel/casing of less than 10 μm, wherein the fuel injectors are not stuck after clean up, and wherein at least 20% of lost power is recovered in 8 hours according to a DW10 test using a sodium salt as a dopant.

8. The method of claim 7, wherein the fuel injected diesel engine is a direct fuel injected diesel engine.

9. The method of claim 7, wherein R contains from 40 to 80 carbon atoms.

10. The method of claim 7, wherein the alkali metal as a salt comprises a sodium carboxylate salt, and wherein the additive is effective to remove sodium carboxylate salt deposits from internal components of the fuel injectors in a high pressure fuel injection system.

11. A method for reducing an amount of alkali metal salt deposits on internal components of a fuel injector for a fuel injected diesel engine comprising operating the diesel engine on a fuel composition comprising (1) a major amount of fuel containing from 0.1 to 2 ppm by weight of alkali metal as a salt, and (2) from 45 to 550 ppm by weight based on a total weight of fuel composition of a fuel additive consisting essentially of a compound of the formula



wherein R is an alkyl or alkenyl group containing from 20 to 170 carbon atoms and wherein the additive has a total acid number (TAN) ranging from 50 to 290 mg KOH/g, and wherein fuel injectors of the fuel injected diesel engine have an average injector hole diameter of less than 160 μm and an average smallest clearance between injector needle and injector barrel/casing of less than 10 μm.

12. The method of claim 11, wherein the fuel injected diesel engine is a direct fuel injected diesel engine.

13. The method of claim 11, wherein the fuel is an ultra low sulfur diesel fuel.

14. The method of claim 11, wherein the fuel composition is essentially devoid of succinimide detergent compounds.

15. The method of claim 11, wherein the fuel additive comprises less than 10 ppm by weight of basic nitrogen from a nitrogen-containing compound.