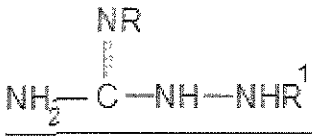
[0005] ULSD now represents about 79% of all distillate fuel supplied in the United States. Also, the Renewable Fuel Standard minimum for biodiesel was raised to 1 billion gallons in 2012. There are indications that the amount of biodiesel required to be used in fuel will be even higher in the future. Accordingly, the changing fuel slate continues to move toward more ULSD (with less solubility for salts that can form) and more biodiesel in the marketplace (another potential source of deposit causing materials in the fuel system).

[0006] In accordance with the disclosure, exemplary embodiments provide a method cleaning up internal components of a fuel injector for a diesel engine. The method includes operating a fuel injected diesel engine on a fuel composition that contains a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from about 5 to about 500 ppm by weight of a reaction product derived from (a) a hydrocarbyl substituted dicarboxylic acid, anhydride, or ester and (b) an amine compound or salt thereof of the formula



wherein R is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 15 carbon atoms, and R^1 is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 20 carbon atoms. The reaction product is characterized by an FTIR spectrum having a peak intensity in a region of from about 1630 cm^{-1} to about 1645 cm^{-1} that ranges from about 5 to about 45% of peak intensities of other peaks in a region of from about 1500 cm^{-1} to about 1800 cm^{-1}.

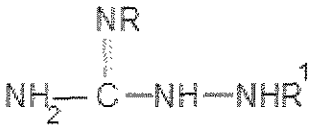
[0006a] In one aspect, there is provided a method for unsticking stuck fuel injectors for a diesel engine comprising operating a fuel injected diesel engine on a fuel composition comprising alkali metal carboxylate salts, a major amount of diesel fuel having a sulfur content of 50 ppm by weight or less and from 20 to 120 ppm by weight of a reaction product derived from (a) a hydrocarbyl substituted dicarboxylic acid, anhydride, or ester and (b) an amine compound or salt thereof of the formula



wherein R is selected from the group consisting of hydrogen and a hydrocarbyl group containing from 1 to 15 carbon atoms, and R^1 is selected from the group consisting of hydrogen and a hydrocarbyl group containing from 1 to 20 carbon atoms, wherein the reaction product is made under conditions sufficient to provide that the reaction product contains less than one equivalent

of an amino triazole group per molecule of reaction product, and wherein the reaction product is characterized by an FTIR spectrum having a peak intensity in a region of from 1630 cm^{-1} to 1645 cm^{-1} that ranges from 5 to 45% of peak intensities of other peaks in a region of from 1500 cm^{-1} to 1800 cm^{-1}.

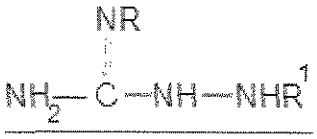
[0007] Another embodiment of the disclosure provides a method for reducing an amount of salt deposits on internal components of a fuel injector for a fuel injected diesel engine. The method includes operating the diesel engine on a fuel composition that contains a major amount of fuel and a minor amount of a reaction product derived from (a) a hydrocarbyl substituted dicarboxylic acid, anhydride, or ester and (b) an amine compound or salt thereof of the formula



wherein R is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 15 carbon atoms, and R^1 is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 20 carbon atoms. The reaction

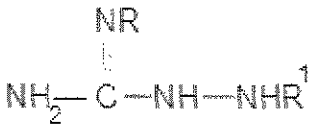
product contains less than one equivalent of an amino triazole group per molecule of reaction product.

[0007a] In another aspect, there is provided a method for unsticking stuck fuel injectors in a fuel injected diesel engine comprising operating the diesel engine on a fuel composition comprising alkali metal carboxylate salts, a major amount of fuel and from 20 to 120 ppm of a reaction product derived from (a) a hydrocarbyl substituted dicarboxylic acid, anhydride, or ester and (b) an amine compound or salt thereof of the formula



wherein R is selected from the group consisting of hydrogen and a hydrocarbyl group containing from 1 to 15 carbon atoms, and R^1 is selected from the group consisting of hydrogen and a hydrocarbyl group containing from 1 to 20 carbon atoms, wherein the reaction product is made under conditions sufficient to provide that the reaction product contains less than one equivalent of an amino triazole group per molecule of reaction product, wherein the reaction product is characterized by an FTIR spectrum having a peak intensity in a region of from 1630 cm^{-1} to 1645 cm^{-1} that ranges from 5 to 45% of peak intensities of other peaks in a region of from 1500 cm^{-1} to 1800 cm^{-1}.

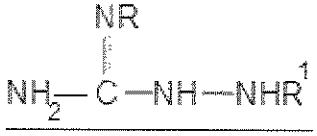
[0008] A further embodiment of the disclosure provides a method for preventing plugging of a fuel filter for fuel injectors of a fuel injected diesel engine. The method includes providing a major amount of fuel and a minor amount of a reaction product derived from (a) a hydrocarbyl substituted dicarboxylic acid, anhydride, or ester and (b) an amine compound or salt thereof of the formula



wherein R is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 15 carbon atoms, and R^1 is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 20 carbon atoms. The reaction product is characterized by an FTIR spectrum having a peak intensity in a region of from about 1630 cm^{-1} to about 1645 cm^{-1} that ranges from about 5 to about 45% of peak intensities of other peaks in a region of from about 1500 cm^{-1} to about 1800 cm^{-1}, and wherein the reaction product contains less than one equivalent of an amino triazole group per molecule of reaction product.

[0009] An advantage of the fuel additive described herein is that the additive may not only reduce the amount of internal deposits forming on direct and/or indirect diesel fuel injectors, but the additive may also be effective to clean up dirty fuel injectors and may prevent the plugging of fuel filters in the fuel supply to the fuel injectors.

[0009a] In another aspect, there is provided a method for preventing plugging of a fuel filter for fuel injectors of a fuel injected diesel engine comprising operating the engine on a major amount of fuel comprising alkali metal carboxylate salts and from 20 mg to 120 mg per Kg of fuel of a reaction product derived from (a) a hydrocarbyl substituted dicarboxylic acid, anhydride, or ester and (b) an amine compound or salt thereof of the formula



wherein R is selected from the group consisting of hydrogen and a hydrocarbyl group containing from 1 to 15 carbon atoms, and R^1 is selected from the group consisting of hydrogen and a hydrocarbyl group containing from about 1 to about 20 carbon atoms, wherein the reaction product is characterized by an FTIR spectrum having a peak intensity in a region of from 1630 cm^{-1} to 1645 cm^{-1} that ranges from 5 to 45% of peak intensities of other peaks in a region of from 1500 cm^{-1} to 1800 cm^{-1}, and wherein the reaction product is made under conditions sufficient to provide that the reaction product contains less than one equivalent of an amino triazole group per molecule of reaction product.

[0010] Additional embodiments and advantages of the disclosure may be set forth in part in the detailed description which follows, and/or may be learned by practice of the disclosure. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the disclosure, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0011] FIG. 1 is a portion of an FTIR spectrum of a prior art product.

[0012] FIG. 2 is a portion of an FTIR spectrum of a reaction product according to the disclosure.