thereof, and (3) mono-ester/mono-acid or metal free mono-acid salt thereof, wherein the reaction product includes at least about 10 molar percent of acid groups based on total moles of the reaction product.

[0004a] In one aspect, there is provided a diesel fuel additive composition comprising: a reaction product of (a) a hydrocarbyl-substituted acylating agent and (b) a reactant selected from the group consisting of ethylenediamine, diethylene triamine, triethylene tetramine, tetraethylene pentamine, pentaethylene hexamine, ammonia, aminoguanidine bicarbonate, guanidine, piperazine, methylpiperazine, amino-pyrimidine, aminotriazole, and aminotetrazole, C_2-C_3-alkanolamines, N-ethanol-ethylenediamine, hydroxyethyl pyridine, and water that provides a reaction product selected from the group consisting (1) a mono-amide/mono-acid or metal free mono-acid salt thereof, and (2) mono-ester/mono-acid or metal free mono-acid salt thereof, wherein the reaction product includes at least 10 molar percent acid groups based on total moles of the reaction product.

[0004b] In another aspect, there is provided a low sulfur diesel fuel comprising the diesel fuel additive composition as defined above.

[0004c] In another aspect, there is provided a method for improving the performance of an engine combusting a diesel fuel having 50 ppm by weight or less sulfur, said method comprising: combining a low sulfur middle distillate fuel with a fuel additive comprising a reaction product of (a) a hydrocarbyl-substituted acylating agent and (b) a reactant selected from the group consisting of ethylenediamine, diethylene triamine, triethylene tetramine, tetraethylene pentamine, pentaethylene hexamine, ammonia, aminoguanidine bicarbonate, guanidine, piperazine, methylpiperazine, amino-pyrimidine, aminotriazole, and aminotetrazole, C_2-C_3-alkanolamines, N-ethanol-ethylenediamine, hydroxyethyl pyridine, and water that provides a reaction product selected from the group consisting (1) a mono-amide/mono-acid or metal free mono-acid salt thereof, and (2) mono-ester/mono-acid or metal free mono-acid salt thereof, wherein the reaction product includes at least 10 molar percent acid groups based on total moles of the reaction product; and combusting the additized fuel in the engine, whereby the performance of the engine is improved relative to the performance of the engine in the absence of the fuel additive.

[0005] In another embodiment of the present disclosure provides a method for improving the performance of an engine combusting a diesel fuel having less than 50 ppm by weight or less sulfur, typically less than about 20 ppm sulfur by weight based on a total weight of the fuel. The method includes combining a low sulfur middle distillate fuel with a fuel additive comprising a reaction product of (a) a hydrocarbyl-substituted acylating agent and (b) a reactant selected from the group consisting of a nitrogen-containing compound, a hydroxyl-containing compound, and water that provides a reaction product selected from the group consisting (1) a mono-amide/mono-acid or metal free mono-acid salt thereof, (2) a diacid or metal free diacid salt thereof, and (3) mono-ester/mono-acid or metal free mono-acid salt thereof, wherein the reaction product includes at least about 10 molar percent acid groups based on total moles of the reaction product. The additized fuel is combusted in the engine, whereby the performance of the engine is improved relative to the performance of the engine in the absence of the fuel additive.

[0006] Yet another embodiment of the disclosure provides a low sulfur diesel fuel composition suitable for a high pressure compression ignition engine. The diesel fuel composition includes a) a major amount of low sulfur diesel fuel, and b) a minor amount of additive for reducing injector and fuel system deposits. The additive is a reaction product of (i) a hydrocarbyl-substituted acylating agent and (ii) a reactant selected from the group consisting of a nitrogen-containing compound, a hydroxyl-containing compound, and water that provides a reaction product selected from the group consisting (1) a mono-amide/mono-acid or metal free mono-acid salt thereof, (2) a diacid or metal free diacid salt thereof, and (3) mono-ester/mono-acid or metal free mono-acid salt thereof, wherein the reaction product includes at least about 10 molar percent acid groups based on total moles of the reaction product.

[0006a] In another aspect, there is provided a low sulfur diesel fuel composition suitable for a high pressure compression ignition engine, comprising: a) a major amount of low sulfur diesel fuel, and b) a minor amount of additive for reducing injector and fuel system deposits, the additive comprising: a reaction product of (i) a hydrocarbyl-substituted acylating agent and (ii) a reactant selected from the group consisting of ethylenediamine, diethylene triamine, triethylene tetramine, tetraethylene pentamine, pentaethylene hexamine, ammonia, aminoguanidine bicarbonate, guanidine, piperazine, methylpiperazine, amino-pyrimidine, aminotriazole, and aminotetrazole, C_2-C_3-alkanolamines, N-ethanol-ethylenediamine, hydroxyethyl pyridine, and water that provides a reaction product selected from the group consisting (1) a mono-amide/mono-acid or metal free mono-acid salt thereof, (2) mono-ester/mono-acid or metal free mono-acid salt thereof, wherein the reaction product includes at least 10 molar percent acid groups based on total moles of the reaction product.

[0007] ~~Other embodiments of the disclosure~~In another aspect, there is provided a method for increasing fuel economy of a vehicle, comprising combusting the diesel fuel composition as defined above~~described herein~~ wherein said fuel economy increase is defined by power recovery, and said power recovery is greater than 50 % as determined by the formula

$$\text{Power recovery} = (DU-CU)/DU$$

wherein DU is a percent power loss during a dirty-up phase without the additive, CU is the percent power loss during a clean-up phase with the fuel additive, and power is measured according to a Coordinating European Council (CEC) F98-08 DW10 test.

[0008] According to one or more embodiments of the disclosure, the additive for use in diesel fuel may provide benefits that include, but are not limited to: a) maintaining clean fuel delivery systems including injectors and fuel filters; b) an ability to clean-up dirty or fouled fuel delivery systems; c) a contribution to boosting or increasing fuel economy; d) reducing combustion system deposits; e) reducing fuel system corrosion; f) and improving lubrication of the fuel system and combustion chamber. The additives of the disclosure may provide similar benefits to other middle distillate fuels, such as home heating oils, marine fuel, and jet fuel.

BRIEF DESCRIPTION OF THE DRAWING

[0009] FIG. 1 is a graphical illustration of power loss over time for an additive according to the disclosure and a comparative additive in a diesel engine.

DETAILED DESCRIPTION OF DISCLOSED EMBODIMENTS

[00010] Further features, embodiments and advantages thereof may be provided by the following detailed description of embodiments of the disclosure. An important feature of the embodiments described herein is that the reaction product used as an additive component of the fuel contains less than about 90 molar percent of an imide and essentially no diamide, or diester components based on a total moles of the reaction product as determined by Fourier transform infrared spectroscopy (FTIR). For example, the reaction product may contain less than 70 molar percent of the imide and suitably from about 0 to about 60 molar percent of imide based on total moles of the reaction product.

[00011] Another important feature of the embodiments described herein is that the reaction product contains at least about 10 molar percent acid groups based on total moles of the reaction product. For example, the reaction product may contain from about 10 to about 20 molar percent or more acid groups. In another example the reaction product may contain from about 20 to about 50 molar percent acid groups. In yet another example, the reaction product may contain about 100 molar percent acid groups.