CLAIMS

1. A fuel composition for use in a gasoline direct injection (GDI) engine, the fuel composition comprising:

a hydrocarbon-based fuel boiling in the gasoline

range;

an amine-based detergent given by formula

$$R_1\text{-}O\text{-}(CH_2)_m\text{-}NHR_2,$$

wherein the amine-based detergent is present in 10 ppm to 750 ppm by weight based on total weight of the fuel composition; wherein R_1 is a hydrocarbyl group having 8 to 20 carbons, R_2 is hydrogen or $(CH_2)_nNH_2$ moiety, and wherein m, n are independently integers having a value of 3 or greater; and

one or more nitrogen-containing detergents,

wherein the one or more nitrogen-containing detergents is an aliphatic hydrocarbyl amine, hydrocarbyl-substituted poly(oxyalkylene)amine, hydrocarbyl-substituted succinimide, Mannich reaction product, nitro and amino aromatic ester of polyalkylphenoxyalkanol, or polyalkylphenoxyaminoalkane;

wherein the combination of the amine-based detergent and the one or more nitrogen-containing detergents mitigates injector fouling in the GDI engine; and

wherein the fuel composition further comprises one or more additives selected from antioxidants, metal deactivators, demulsifiers, oxygenates, antiknock agents, dispersants, pour point depressants, and flow improvers.

2. The fuel composition of claim 1, wherein R_1 is linear or branched.

3. The fuel composition of claim 1, wherein the amine-based detergent or the one or more nitrogen-containing detergents is a monoamine or a polyamine.

4. The fuel composition of claim 1, wherein the one or more nitrogen-containing detergents is present in 50 ppm to 2500 ppm of the fuel composition.

5. A method of controlling injector fouling in a gasoline direct injection (GDI) engine, the method comprising:

supplying to the GDI engine a fuel composition comprising:

a hydrocarbon-based fuel boiling in the gasoline range;

an amine-based detergent given by formula

R_1-O-$(CH_2)_m$-NHR_2,

wherein the amine-based detergent is present in 10 ppm to 750 ppm by weight based on total weight of the fuel composition; wherein R_1 is a hydrocarbyl group having 8 to 20 carbons, R_2 is hydrogen or $(CH_2)_nNH_2$ moiety, and wherein m, n are independently integers having a value of 3 or greater;

one or more nitrogen-containing detergent wherein the one or more nitrogen-containing detergents is an aliphatic hydrocarbyl amine, hydrocarbyl-substituted poly(oxyalkylene)amine, Mannich reaction product, hydrocarbyl-substituted succinimide, nitro and amino aromatic ester of polyalkylphenoxyalkanol, or polyalkylphenoxyaminoalkane; and

wherein the fuel composition further comprises antioxidants, metal deactivators, demulsifiers, oxygenates, antiknock agents, dispersants, pour point depressants, or flow improvers.

6. The method of claim 5, wherein R_1 is linear or branched.

7. The method of claim 5, wherein the amine-based detergent or the one or more nitrogen-containing detergent is a monoamine or a polyamine.

8. The method of claim 5, wherein the one or more nitrogen-containing detergent is present in 50 ppm to 2500 ppm of the fuel composition.