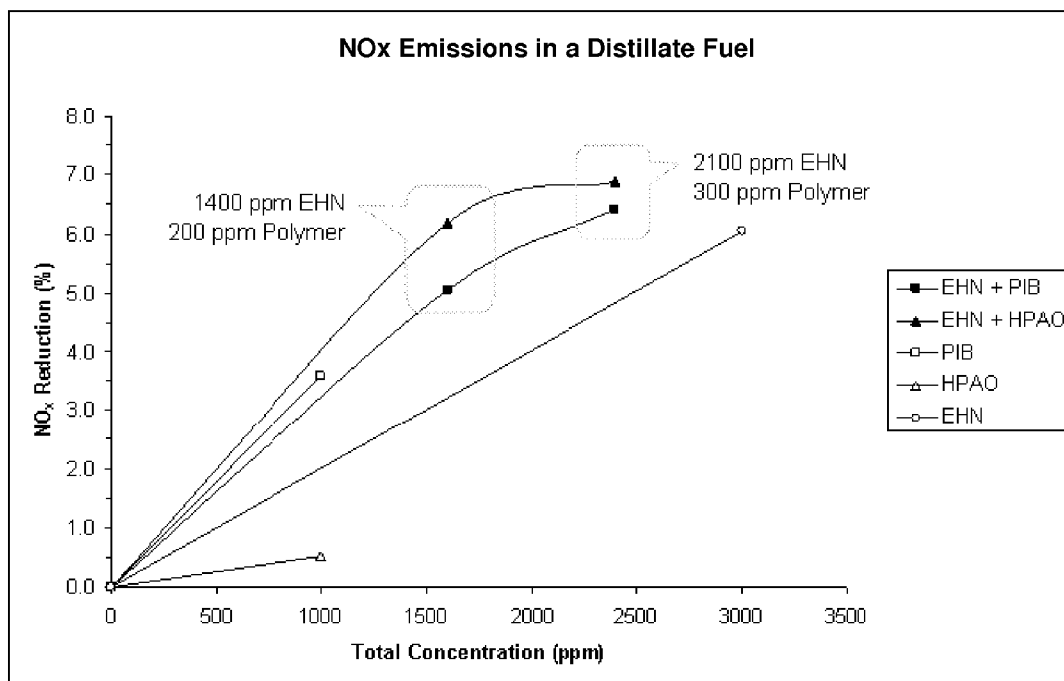


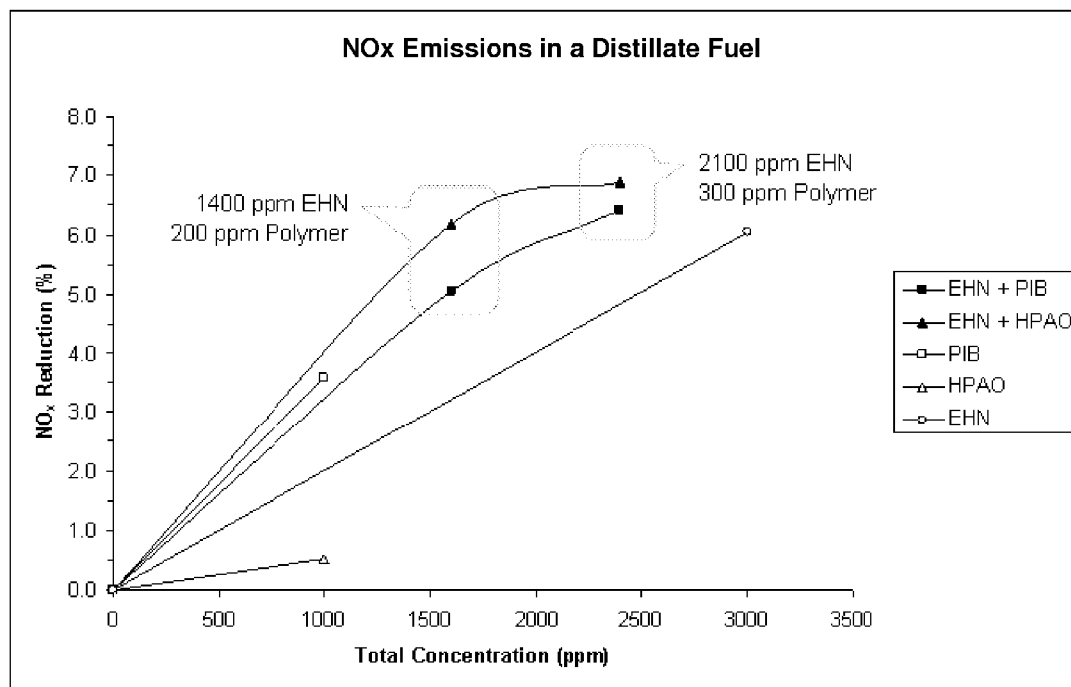


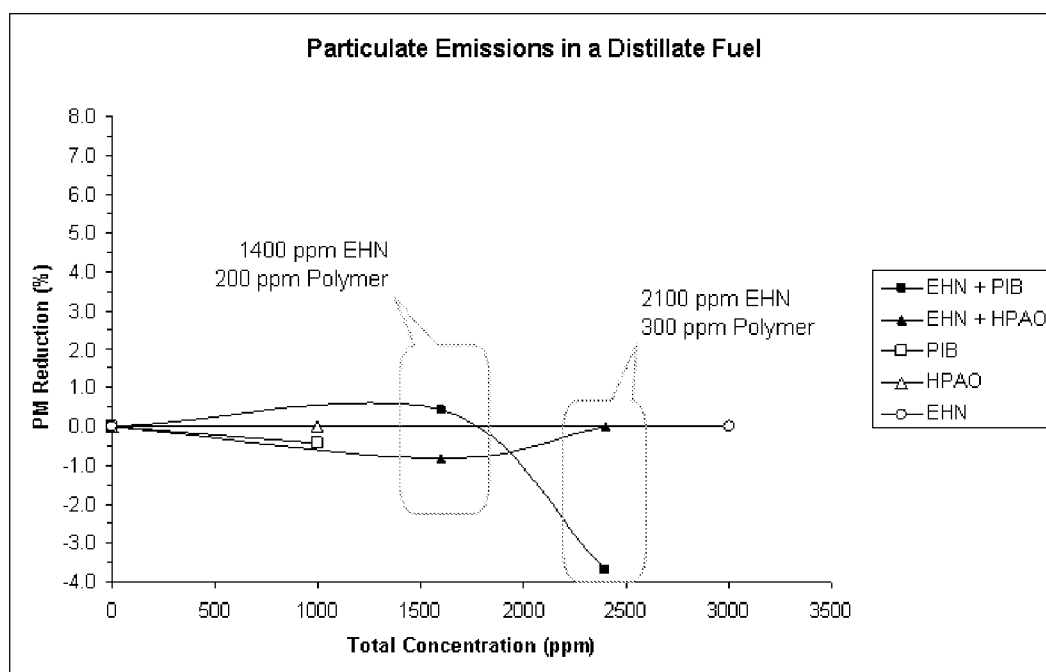
US 20120066964A1

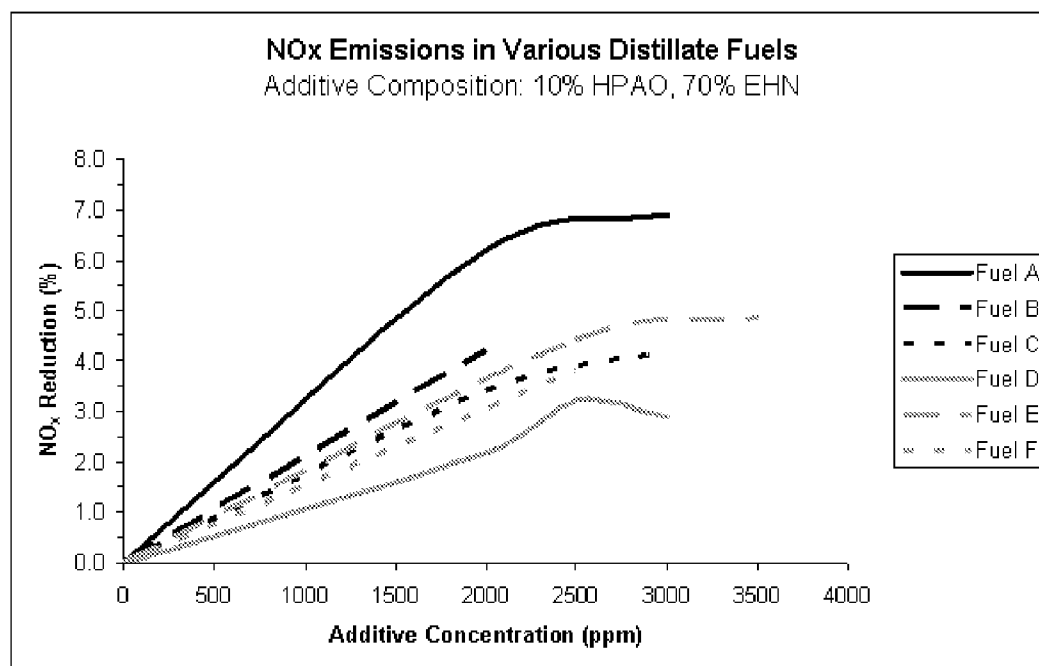
(19) **United States**(12) **Patent Application Publication**
Harrell et al.(10) **Pub. No.: US 2012/0066964 A1**(43) **Pub. Date: Mar. 22, 2012**(54) **ADDITIVES FOR REDUCTION OF EXHAUST
EMISSIONS FROM COMPRESSION
IGNITION ENGINES**(60) Provisional application No. 60/940,914, filed on May
30, 2007.**Publication Classification**(75) Inventors: **Bradley G. Harrell**, Pearland, TX
(US); **Michael J. Zetlmeisl**, Katy,
TX (US); **Christopher Gallagher**,
The Woodlands, TX (US);
Jianzhong Yang, Missouri City, TX
(US); **Andrew J. McCallum**, Katy,
TX (US)(51) **Int. Cl.**
C10L 1/18 (2006.01)
C10L 1/23 (2006.01)
C10L 1/16 (2006.01)(52) **U.S. Cl.** **44/322; 585/14; 44/324**(57) **ABSTRACT**(73) Assignee: **BAKER HUGHES
INCORPORATED**, Houston, TX
(US)(21) Appl. No.: **13/162,761**(22) Filed: **Jun. 17, 2011****Related U.S. Application Data**(63) Continuation-in-part of application No. 12/128,918,
filed on May 29, 2008, now abandoned.

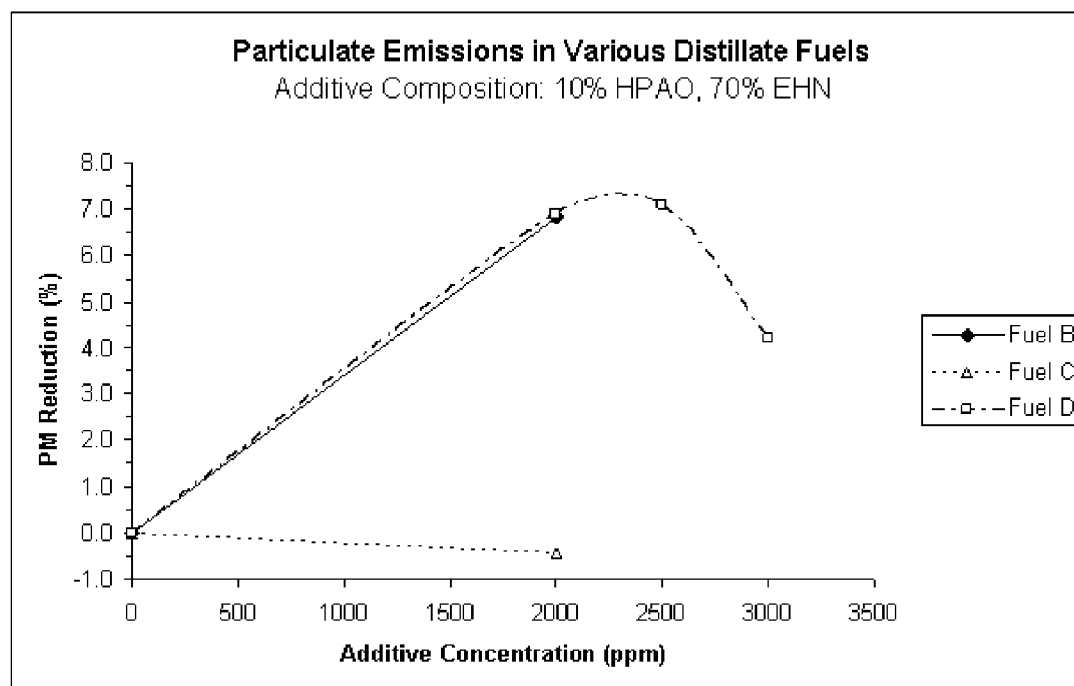
Exhaust emissions resulting from the combustion of hydrocarbon fuels in compression ignition engines may be reduced using a homopolymer that may be polyisobutylene, polypropylene, and/or hyperbranched polyalpha-olefins. The homopolymer may have a molecular weight of from about 1600 to about 275,000. Optionally, an alkyl nitrate such as 2-ethylhexylnitrate (2EHN), and/or a peroxide, such as hydrogen peroxide, may also be used together with the homopolymer. Both NO_x and particulate matter emissions (PM) may be reduced using ppm quantities of the additive compositions; alternatively, NO_x emissions may be lowered or reduced while PM emissions do not substantially increase.



**FIG. 1**

**FIG. 2**

**FIG. 3**

**FIG. 4**

ADDITIVES FOR REDUCTION OF EXHAUST EMISSIONS FROM COMPRESSION IGNITION ENGINES

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation-in-part application from U.S. patent application Ser. No. 12/128,918, filed May 29, 2008, which claims the benefit of U.S. Provisional Patent Application No. 60/940,914 filed May 30, 2007.

TECHNICAL FIELD

[0002] The present invention relates to additives for distillate fuels, and more particularly relates, in one embodiment to reducing exhaust emissions for hydro-carbon fuels using chemical additives.

TECHNICAL BACKGROUND

[0003] It is well known that considerable effort has been expended reducing the exhaust emissions from compression ignition (e.g. internal combustion) engines. These exhaust emissions are the products of burning the fuel in the engine, emitted from an exhaust system. The major emissions include hydrocarbons, which are unburned or partially burned fuels, nitrogen oxides (generally abbreviated NOx) which are generated when nitrogen in the air reacts with oxygen under the high temperature and pressure conditions inside the engine, carbon monoxide (CO) which is a product of incomplete combustion, and carbon dioxide (CO₂) which is a product of the complete combustion of hydrocarbons.

[0004] Additives to fuels are known to reduce undesirable emissions. There are many fuel additives that claim to lower emissions, such as particulate matter, unburnt hydrocarbon, and NOx. Various organo-metallic and totally organic formulations have been proposed and tried. Furthermore, diverse mechanisms have been proposed for their effectiveness.

[0005] It has been found to be difficult to simultaneously reduce particulate matter (PM) emissions and NOx emissions, particularly in diesel fuels. Unfortunately, with some additives, as the PM is lowered, NOx emissions rise, and vice versa with others. There is some promise that ethanol fuel additives may help reduce both PM and NOx simultaneously under certain conditions.

[0006] Thus, it would be desirable if other additives could be developed to reduce the emissions of distillate fuels upon combustion.

SUMMARY

[0007] There are provided, in one non-limiting form, compositions for reducing the emissions of distillate fuels that includes a homopolymer such as polyisobutylene (PIB), polypropylene (PP), and/or a hyperbranched polymer, where the homopolymer has a molecular weight of from about 1600 to about 275,000. Combinations of these polymeric materials with an alkyl nitrate, such as 2-ethylhexylnitrate (2EHN), and/or a peroxide, such as hydrogen peroxide, are also useful.

[0008] There are further provided in another non-restrictive version distillate fuels, such as diesel fuels, gasoline, jet fuels, or kerosene, having reduced emissions, that contains an effective amount of a composition to reduce emissions of a homopolymer that may be polyisobutylene, polypropylene, and/or a hyperbranched polymer, where the homopolymer

has a molecular weight of from about 1600 to about 275,000, and optionally an alkyl nitrate and/or a peroxide.

[0009] Also provided in another non-limiting embodiment are methods for reducing emissions of a distillate fuel by adding to the fuel an effective amount of a composition that includes a homopolymer that may be polyisobutylene, polypropylene, and/or a hyperbranched polymer, where the homopolymer has a molecular weight of from about 1600 to about 275,000, and optionally an alkyl nitrate and/or a peroxide.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a graph of NOx emissions in a distillate fuel showing NOx reduction measured as % as a function of total concentration of the additives herein;

[0011] FIG. 2 is a graph of particulate matter emissions measured as a function of the total concentration of the additives for the fuels of FIG. 1;

[0012] FIG. 3 is another graph of NOx emissions in a distillate fuel showing NOx reduction measured as % as a function of total concentration of an additive composition containing 10% hyperbranched polyalpha-olefin (HPAO) and 70% 2-ethylhexyl nitrate (EHN), the balance being solvent; and

[0013] FIG. 4 is a graph of particulate emissions (PM) in a distillate fuel showing NOx reduction measured as % as a function of total concentration of an additive composition containing 10% hyperbranched polyalpha-olefin (HPAO) and 70% 2-ethylhexyl nitrate (EHN), the balance being solvent.

DETAILED DESCRIPTION

[0014] The methods and compositions herein relate to reducing the amount of exhaust emissions resulting from the combustion of hydrocarbon fuels in compression ignition engines such as internal combustion engines. In particular, the additives reduce NOx emissions and/or particulate matter. More specifically, the methods and compositions herein concern a fuel additive formulation that includes a polymer. Suitable polymers are homopolymers including, but not necessarily limited to, polyisobutylene, polypropylene, hyperbranched polymers, and in particular hyperbranched polyalpha-olefins (PAO), and the like. In one non-restrictive version, the hyperbranched polyalpha-olefins may be hyperbranched polymers of C4-C30 alpha-olefins, where the alpha-olefins may be acid- or alcohol-functionalized, and mixtures and derivatives thereof. In one non-limiting embodiment, the polymer presence lowers NOx and in many embodiments also lowers particulate matter (PM).

[0015] The additive composition herein may also optionally contain a component that may be an alkyl nitrate and/or a peroxide. Suitable alkyl nitrates include, but are not necessarily limited to, 2-ethylhexyl nitrate (2EHN), CH₃(CH₂)₅CH(C₂H₅)CH₂ONO₂, iso-propyl nitrate, iso-amyl nitrate, iso-hexylnitrate, cyclohexyl nitrate, dodecyl nitrate, diglycol nitrate and tetraglycol nitrate and the like. Ether nitrates and fatty acid nitrates may also be useful. The alkyl nitrate may function to primarily lower the NOx emissions although reduction in PM may also be expected. Alternatively, NOx emissions may be lowered by the compositions herein without appreciably raising PM levels, which would also be an advantage and an improvement.

[0016] The additive composition may also optionally include a peroxide, in place of or in addition to the alkyl

nitrate. Suitable peroxides include, but are not necessarily limited to, hydrogen peroxide, di-tertiary butyl peroxide, and benzoyl peroxide and the like. Further, some synergism has been found between the homopolymer and the alkyl nitrate and/or peroxide. Known cetane boosters for use in distillate fuels include 2-ethylhexyl nitrate, tertiary butyl peroxide, diethylene glycol methyl ether, cyclohexanol, and mixtures thereof. Conventional, known ignition accelerators include hydrogen peroxide, benzoyl peroxide, di-tert-butyl peroxide, and the like.

[0017] By hyperbranched polyalpha-olefins are meant polymers prepared by polymerizing hydrocarbons under free radical conditions at low pressures. Suitable free radical catalysts include, but are not necessarily limited to, metallocenes and transition metal catalysts, along with peroxide catalysts and Ziegler-Natta catalysts. The polymers are unique in that although hydrocarbon polymers generally have higher molecular weight, greater viscosity and greater hardness than the starting hydrocarbon these polymers generally have higher melting points and congealing points than the starting hydrocarbons. The hydrocarbons employed are primarily alpha-olefins of the formula $RCH=CH_2$ but may also include alpha-olefins having vinylidene structures, internal olefins and saturates, where R is an alkyl or alkylene group, including those having vinylidene structures. Suitable hyperbranched polyalpha-olefins are those made according to the methods described in U.S. Pat. Nos. 4,060,569; 4,239,546 and 6,776,808, all incorporated by reference herein in their entirety. The hyperbranched polyalpha-olefins are considered homopolymers herein under the classic definition because they are made from a single monomer. Suitable hyperbranched polyalpha-olefins herein may have a number average molecular weight (M_n) of from about 100 to about 275,000, alternatively a lower threshold of about 150 and independently an upper threshold of about 250,000, and in another non-limiting embodiment from about 200 independently up to about 175,000, or even up to about 125,000. Alternative lower thresholds to be used within these ranges include, but are not necessarily limited to, about 1600, about 1700 and about 1800, even about 2000. The patents noted above do describe copolymers which are not encompassed by the additive compositions and methods herein.

[0018] Hyperbranched polyalpha-olefins have a unique physical and chemical structure compared with conventional homopolymers of ethylene, propylene, butylene (1- or 2-), pentylene or isobutylene. Hyperbranched polyalpha-olefins have long alkyl groups on tertiary carbons and "branches on branches". By "long alkyl groups" is meant alkyl groups of from 4 to 50 carbon atoms; alternately from 4 to 24 carbon atoms, and in another non-limiting embodiment, from 4 to 14 carbon atoms. Hyperbranched polyalpha-olefins are expected to have at least two alkyl branches on at least two other alkyl branches, whereas conventional homopolymers noted above have no such "branching on branching". This is in contrast to polyisobutylene, which at most has methyl "branches". Indeed, the maximum alkyl branch length from the conventional homopolymers in the list above is C3, and again, they have no branches on branches.

[0019] Other polymers that may also be useful in the additive compositions herein include, but are not necessarily limited to, isotactic polypropylene (such as ones having a weight average molecular weight in the range of about 1600 to about 2000; alternatively about 1700 to about 2000) or higher

molecular weight hyperbranched polymer products than those described above. Polymer alone without the 2EHN may be useful.

[0020] Suitable homopolymers include, but are not necessarily limited to polyisobutylene, polypropylene, hyperbranched polymers, and mixtures thereof, where the homopolymer has a M_n molecular weight of from about 1600 to about 275,000; alternatively the lower M_n threshold is about 1600, about 1700, about 1800 or about 2000, where alternatively the upper threshold, in combination with any of the lower thresholds, may be about 275,000, about 250,000, about 175,000, or about 125,000 to give acceptable alternative M_n ranges.

[0021] The methods herein relate to additive compositions for distillate fuels, as contrasted with products from resid. In the context herein, distillate fuels include, but are not necessarily limited to diesel fuel, kerosene, gasoline, jet fuel, and the like. It will be appreciated that distillate fuels include blends of conventional hydrocarbons meant by these terms with oxygenates, e.g. alcohols, such as methanol, ethanol, and other additives or blending components presently used in these distillate fuels, such as MTBE (methyl-tert-butyl ether), or that may be used in the future. In one non-limiting embodiment herein, distillate fuels include low sulfur fuels, which are defined as having a sulfur content of 0.2% by weight or less, and in another non-limiting embodiment as having a sulfur content of about 0.0015 wt. % or less—such as the so-called "ultra low sulfur" fuels. Particularly preferred hydrocarbon fuels herein are diesel and kerosene. It is expected that a more conventional diesel fuel (i.e. with an aromatic content of >28%) treated with the additive composition herein will be equivalent in emissions to a Texas Low Emissions Diesel (TxLED) fuel with <10% aromatic content.

[0022] Generally, in one non-limiting embodiment herein the composition for improving the emissions of distillate fuels is a mixture or blend of 2EHN (or a peroxide component) and at least one of the homopolymers. In another non-restrictive version herein the homopolymer is present in the fuel in the range of about 20 to about 2500 ppm, in one non limiting embodiment from about 20 independently up to about 300 ppm; alternatively from about 20 independently up to about 150 ppm. The alkyl nitrate, particularly 2EHN, may be present in the fuel in the range of about 100 to about 3000 ppm, alternatively from about 500, independently up to about 1500 ppm. In one non-limiting embodiment, the volume ratio of homopolymer to the component ranges from about 1:1 to about 1:100, and alternatively the volume ratio of homopolymer to the component ranges from about 1:2 to about 1:10; and in one particularly suitable ratio, about 1:7.

[0023] Typically, a solvent may be advantageously used in the compositions herein, where the solvent may be aromatic solvents and pure paraffinic solvents. Aromatic solvents are particularly preferred. The proportion of solvent in the total fuel additive composition may range from about 0 to 90 weight %; in another non-restrictive embodiment, the solvent may range from a lower threshold of about 15 wt % independently to an upper threshold of 45 wt %. The use of a solvent is optional. In some non-limiting embodiments, no solvent is used or desired. A non-restrictive example would be 87.5% 2EHN and 12.5% HPAO with no solvent (a 7:1 ratio of active components). Specific examples of suitable solvents include, but are not limited to paraffins and cycloparaffins, aromatic naphtha, kerosene, diesel, gasoline, xylene, toluene, alcohols (e.g. 2-ethylhexanol), and the like.

[0024] It will be appreciated that the methods and compositions herein also encompass distillate fuels containing the additive compositions described herein, as well as methods of improving the emissions properties of distillate fuels using the additive compositions described herein.

[0025] Other, optional components of the distillate fuels in non-limiting embodiments may include, but are not necessarily limited to detergents, pour point depressants, cetane improvers, lubricity additives, dehazers, cold operability additives, conductivity additives, biocides, dyes, and mixtures thereof. Particularly useful components may include condensation reaction products of aldehydes and amines which are useful as antioxidants and are effective to lower PM and unburnt hydrocarbon (HC). A specific non-limiting example is the condensation reaction product between formaldehyde and di-n-butylamine. In another non-limiting embodiment, water is explicitly absent from the additive composition.

[0026] The invention will be illustrated further with respect to the following non-limiting Examples that are included only to further illuminate the invention and not to restrict it.

Examples 1-3

[0027] Additive compositions expected to be useful herein include, but are not necessarily limited to the following outlined in Table I:

TABLE I

Fuel Additive Compositions to Reduce Exhaust Emissions				
Ex.	Polymer	2EHN	Solvent	Other
1	10 wt % PIB	70 wt %	15 wt % aromatic 5 wt % 2-ethylhexanol	
2	10 wt % hyper-branched polymer	70 wt %	15 wt % aromatic 5 wt % 2-ethylhexanol	
3		70 wt %	10 wt % aromatic	20 wt % Product Q

The hyperbranched polymer is a polyalpha-olefin having a molecular weight of about 2800. The 2-ethylhexanol (2EH) was added as a solvent to improve the low temperature stability of the additive formulation. Product Q is a condensation reaction product between formaldehyde and di-n-butylamine.

Examples 4-9

[0028] Other additive compositions expected to be useful herein include, but are not necessarily limited to those outlined in Table II:

TABLE II

Component Description	Wt-%
Ex. 4	
PIB, 1500 MW	10
2-Ethylhexyl nitrate	70
Aromatic solvent	15
2-Ethylhexanol	5
Ex. 5	
Hyperbranched PAO	10
2-Ethylhexyl nitrate	70
Aromatic solvent	15
2-Ethylhexanol	5

TABLE II-continued

Component Description	Wt-%
Ex. 6	
2-Ethylhexyl nitrate	70
bis-(dibutyl)diaminomethane	20
Aromatic solvent	10
Ex. 7	
PIB, 1500 MW	50
Aromatic solvent	45
2-Ethylhexanol	5
Ex. 8	
Hyperbranched PAO	50
Aromatic solvent	45
2-Ethylhexanol	5
Ex. 9	
PIB, 1500 MW	10
2-Ethylhexyl nitrate	70
Aromatic solvent	10
Polyester diol (for lubricity)	5
2-Ethylhexanol	5

[0029] The test data in the Figures discussed below was developed using a 1991 DDC Series 60 (Serial No. 06R0038671) heavy duty diesel engine mounted in a transient-capable test cell. This engine had an in-line, six cylinder configuration rated for 365 hp at 1800 rpm, was turbocharged, and used a laboratory water to air heat exchanger for a charge air intercooler. The exhaust was routed to a full flow constant volume sampler that utilized a positive displacement pump. Total flow in the tunnel was maintained at a nominal flow rate of about 2000 SCFM. Sample zone probes for particulate matter (PM), heated oxides of nitrogen (NOx), heated hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide (CO₂) measurements were connected to the main tunnel. Probes for background gas measurement were connected downstream of the dilution air filter pack, but upstream of the mixing section. The dilution system was equipped with pressure and temperature sensors at various locations in order to obtain all necessary information required by the U.S. Code of Federal Regulation (40 CFR, Part 86, Subpart N).

[0030] FIG. 1 depicts the NOx mitigation that is achieved with various formulations of HPAO and PIB, alone and in combination with EHN in a compression ignition fuel. The y-axis indicates the percent NOx reduction. The x-axis indicates the total concentration in ppm (wt.) of the additive component or components for a particular test. FIG. 1 illustrates several points:

[0031] 1. All of the formulations mitigated NOx, at least to some extent.

[0032] 2. PIB alone performed considerably better than HPAO alone.

[0033] 3. The combinations of polymer plus EHN performed better than polymer alone or EHN alone.

[0034] 4. The HPAO plus EHN combination performed better than the corresponding combination with PIB, in spite of the fact that PIB alone performed better than HPAO alone.

[0035] 5. The HPAO plus EHN combination performed better at 2000 ppm than EHN alone at 3000. This point becomes even more significant when the fact is considered that the combination product at 2000 ppm has a

total of 1600 ppm active components (1400 EHN and 200 HPAO). This clearly indicates a synergism between HPAO and EHN.

[0036] FIG. 2 depicts the PM emissions that were achieved with the distillate fuels and the additives of FIG. 1. HPAO and EHN alone did not affect PM. PIB alone gave slightly increased PM (slightly negative reduction). It may be noted that at about 1600 ppm total concentration, the fuel with 1400 ppm EHN and 200 ppm PIB had improved PM reduction. At about 2400 ppm total concentration, 2100 ppm EHN and 300 ppm PIB, the PM emissions increased (negative reduction). At about 1600 ppm total concentration, 1400 EHN and 200 ppm HPAO gave somewhat increased PM emission, but at about 2400 ppm total concentration, 2100 ppm EHN and 300 PIB gave no PM change.

[0037] FIG. 3 depicts data on one formulation, 10% HPAO/70% EHN in six different distillate fuels that met ASTM D975 specifications, but varied in composition, at various dosages. The y-axis is the same as in FIG. 1, but the x-axis is ppm of the additive as formulated. In every case the effectiveness of the additive is clear, but the degree of effectiveness varies from fuel to fuel. For instance, at an additive dosage of 2500 ppm (as formulated) NOx reduction was as high as 7% in the fuel with the best response and as low as about 3% in the fuel with the worst response.

[0038] In addition to the effectiveness of the HPAO and HPAO-EHN combinations in mitigating NOx, there is clear evidence that these components do so without increasing particulate matter to any significant extent and, in fact, in most cases it actually lowers PM. FIG. 4 is illustrative of this point. In two of the three fuels PM was mitigated by as much as about 7%, whereas in one fuel there was a very slight, and most likely not statistically significant, increase in PM. Another different fuel, Fuel E, gave a more pronounced negative reduction in PM (increase in PM) than Fuel C. Without being limited to any particular explanation, it may be that this Fuel E behavior was due to high aromatics content and an unusually high specific gravity.

[0039] In the foregoing specification, the invention has been described with reference to specific embodiments thereof, and has been demonstrated as effective for reducing the emissions of fuels. However, it will be evident that various modifications and changes can be made thereto without departing from the broader spirit or scope of the invention as set forth in the appended claims. Accordingly, the specification is to be regarded in an illustrative rather than a restrictive sense. For example, specific combinations of polymers optionally together with alkyl nitrates and/or peroxides falling within the claimed parameters, but not specifically identified or tried in a particular composition to improve the emissions of fuels herein, are expected to be within the scope of this invention. Certain compositions under certain conditions may serve to lower NOx emissions without any substantial increase in PM emissions or with substantially unchanged PM emissions. It is anticipated that the compositions of this invention may also impart to the engines in which they are used as emissions reducers, greater horsepower, and better fuel economy as a result of less friction, whether they are used in diesel or gasoline engines.

[0040] The present invention may suitably comprise, consist or consist essentially of the elements disclosed and may be practiced in the absence of an element not disclosed.

[0041] The words “comprising” and “comprises” as used throughout the claims is to interpreted “including but not limited to”.

What is claimed is:

1. A method for reducing emissions of a distillate fuel comprising adding to the distillate fuel an effective amount of an additive composition for reducing the emissions of the distillate fuel, the additive composition comprising a homopolymer selected from the group consisting of polyisobutylene, polypropylene, hyperbranched polymers, and mixtures thereof, where the homopolymer has a molecular weight of from about 1600 to about 275,000.

2. The method of claim 1, where the additive composition further comprises a component selected from the group consisting of an alkyl nitrate, a peroxide and combinations thereof.

3. The method of claim 2 where the effective amount of the component ranges from about 100 to about 3000 ppm and the effective amount of the homopolymer ranges from about 20 to about 2500 ppm, both based on the total distillate fuel.

4. The method of claim 1 where the fuel has reduced NOx and/or particulate matter emissions as compared to an otherwise identical fuel absent the additive composition.

5. The method of claim 1 where the fuel has reduced NOx and particulate matter emissions are substantially the same as or lower compared to an otherwise identical fuel absent the additive composition.

6. A method for reducing emissions of a distillate fuel comprising adding to the distillate fuel an additive composition comprising:

from about 20 to about 2500 ppm, based on the total distillate fuel, of a homopolymer selected from the group consisting of polyisobutylene, polypropylene, hyperbranched polyalpha-olefins, and mixtures thereof, where the homopolymer has a molecular weight of from about 1600 to about 275,000; and

from about 100 to about 3000 ppm, based on the total distillate fuel, of a component selected from the group consisting of an alkyl nitrate, a peroxide and combinations thereof.

7. The method of claim 6 where the fuel has reduced NOx and/or particulate matter emissions as compared to an otherwise identical fuel absent the additive composition.

8. The method of claim 6 where the fuel has reduced NOx and particulate matter emissions are substantially the same as or lower compared to an otherwise identical fuel absent the additive composition.

9. An additive composition for reducing the emissions of distillate fuels comprising:

a homopolymer selected from the group consisting of polyisobutylene, polypropylene, hyperbranched polymers, and mixtures thereof, where the homopolymer has a molecular weight of from about 1600 to about 275,000; and

a component selected from the group consisting of an alkyl nitrate, a peroxide, and combinations thereof.

10. The composition of claim 9 where the volume ratio of homopolymer to the component ranges from about 1:1 to about 1:100.

11. The composition of claim 9 where the component is an alkyl nitrate selected from the group consisting of 2-ethylhexyl nitrate (2EHN), iso-propyl nitrate, iso-amyl nitrate, iso-hexyl nitrate, cyclohexyl nitrate, dodecyl nitrate, diglycol nitrate and tetraglycol nitrate.

- 12.** A distillate fuel comprising:
a hydrocarbon selected from the group consisting of diesel fuel, gasoline, jet fuel, and kerosene; and
an effective amount of an additive composition for reducing the emissions of the distillate fuel comprising a homopolymer selected from the group consisting of polyisobutylene, polypropylene, hyperbranched polymers, and mixtures thereof, where the homopolymer has a molecular weight of from about 1600 to about 275,000.
- 13.** The distillate of claim **12** where the additive composition further comprises a component selected from the group consisting of an alkyl nitrate, a peroxide, and combinations thereof.
- 14.** The distillate fuel of claim **13** where the effective amount of the component ranges from about 100 to about 3000 ppm and the effective amount of the homopolymer ranges from about 20 to about 2500 ppm, both based on the total distillate fuel.
- 15.** The distillate fuel of claim **12** where the fuel has reduced NO_x and/or particulate matter emissions as compared to an otherwise identical fuel absent the additive composition.
- 16.** The distillate fuel of claim **12** where the fuel has reduced NO_x and particulate matter emissions are substantially the same or lower as compared to an otherwise identical fuel absent the additive composition.
- 17.** The distillate fuel of claim **13** where the component is an alkyl nitrate selected from the group consisting of 2-ethyl-

ylhexyl nitrate (2EHN), iso-propyl nitrate, iso-amyl nitrate, iso-hexyl nitrate, cyclohexyl nitrate, dodecyl nitrate, diglycol nitrate and tetraglycol nitrate.

- 18.** A distillate fuel comprising:
a hydrocarbon selected from the group consisting of diesel fuel, gasoline, jet fuel and kerosene; and
an effective amount of an additive composition for reducing the emissions of the distillate fuel comprising
a homopolymer selected from the group consisting of polyisobutylene, polypropylene, hyperbranched polymers, and mixtures thereof, where the homopolymer has a molecular weight of from about 1600 to about 275,000; and
a component selected from the group consisting of an alkyl nitrate, a peroxide, and combinations thereof;
where the fuel has reduced NO_x and/or particulate matter emissions as compared to an otherwise identical fuel absent the additive composition.
- 19.** The distillate fuel of claim **18** where the effective amount of the component ranges from about 100 to about 3000 ppm and the effective amount of the homopolymer ranges from about 20 to about 2500 ppm, both based on the total distillate fuel.
- 20.** The distillate fuel of claim **18** where the component is an alkyl nitrate selected from the group consisting of 2-ethylhexyl nitrate (2EHN), iso-propyl nitrate, iso-amyl nitrate, iso-hexyl nitrate, cyclohexyl nitrate, dodecyl nitrate, diglycol nitrate and tetraglycol nitrate.

* * * * *