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(71) Applicant: **Exxon Research and Engineering Company**
P.O.Box 390 180 Park Avenue
Florham Park New Jersey 07932(US)

(72) Inventor: **Vardi, Joseph**
85 Orchard Road
Demarest New Jersey 07627(US)
Inventor: **Zimmerman, Abraham Abba**
1 Canterbury Court
Warren New Jersey 07060(US)

(74) Representative: **Somers, Harold Arnold et al**
ESSO Engineering (Europe) Ltd. Patents & Licences Apex Tower High Street
New Malden Surrey KT3 4DJ(GB)

(54) Improved fuel composition.

(57) An additive package for reducing and/or preventing injector fouling in a multiport fuel injection means is described. The additive package preferably comprises a particularly described amine oxide, one or more particularly described demulsifiers, and a particularly described solvent system.

IMPROVED FUEL COMPOSITION

BACKGROUND OF THE INVENTION

This invention is directed to an anti-fouling fuel composition. More specifically, the present invention is directed at a fuel composition having particular applicability in minimizing and/or preventing injector fouling in gasoline engines equipped with electronically controlled multiport fuel injectors.

Over the past several years, improvements have been made in the performance of internal combustion engines. One of the most significant improvements which has been made has been the widespread use of fuel injection to improve the performance and fuel economy of internal combustion engines. While carburetor-equipped internal combustion engines admix the air and fuel for distribution through a manifold to all of the cylinders, in a fuel injected engine the fuel is injected into the manifold close to the intake valve of each cylinder for combustion. Fuel injection systems are of two basic types, mechanically controlled and electronically controlled. The early fuel injected engines were controlled mechanically, i.e., the operation of each injector was controlled by pressure. Recently, however, the use of electronically controlled fuel injection engines has become increasingly widespread. In an electronically controlled fuel injection system sensors disposed in the exhaust are employed to maintain the air to fuel ratio within narrow limits. Electronically controlled fuel injection systems offer the same performance and fuel economy benefits that would be achieved with mechani cally controlled fuel injection systems and also serve to more closely regulate fuel-air mixtures to thereby enable the catalytic converter to oxidize carbon monoxide and hydrocarbons to carbon dioxide and simultaneously to reduce nitrogen oxides and thus meet emissions control legislation. Such legislation imposing as it did strict control of exhaust pollutants utimately led to the development and widespread application of new technologies such as electronic fuel injection.

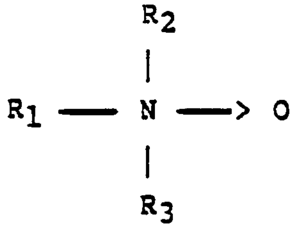
It has been found that the electronically controlled fuel injector systems have small port openings which are prone to fouling by deposits. These deposits are believed to occur, at least in part, by gasoline and oil vapor, which is present in close proximity to the injector tip, becoming baked onto the hot surfaces of the injector pintle and on the surfaces of the annulus surrounding the pintle when the engine is shut off. These deposits restrict the fuel flow to that particular cylinder. This, in turn, causes a sensor disposed in the exhaust to detect a higher than desired oxygen to fuel ratio. The sensor will attempt to correct this condition by increasing the amount of fuel injected into all of the cylinders. This, in turn, will result in a richer than desired fuel to air ratio in the exhaust. The sensor then will attempt to correct this by decreasing the amount of fuel injected into each cylinder. This cyclical adjustment of the fuel to air ratio ranging between too lean a mixture and too rich a mixture can at times result in poor operating performance of the vehicle. In addition, close tolerances in this new type of injector and concurrently higher underhood temperature also tend to enhance deposit formation resulting in poor vehicle driveability and exhaust pollutant emission levels which exceed the maximum levels set by emisisons control legislation.

It has been found that conventional gasoline detergents, which have proven effective in preventing and/or eliminating carburetor deposits are not particularly effective in removing and/or preventing deposit build-up that may occur in electronically controlled fuel injection systems. Presently available methods for removing deposits from fuel injector orifices typically comprise either mechanically cleaning the injectors or the addition to the fuel of relatively large quantities of particular additives. Mechanical cleaning, which may involve either the complete removal of the injector for manual deposit removal or the use of polar solvents for flushing the deposits free, is not desired because of the relatively high cost and inconvenience. Currently available additives are not particularly desirable because product recommendations indicate they must be used at relatively high concentrations, i.e. about one to about two tons per thousand barrels of fuel.

To be useful commercially a gasoline additive for reducing and/or preventing injector port fouling must be effective at low concentration, must not significantly affect the combustion characteristics of the fuel and must not foul the catalytic converter catalyst.

The additive also should not promote excessive emulsification, and should not promote the formation of two organic phases.

Additives have been added to gasoline to improve certain properties of the fuel. U.S. Patent No. 3,387,953 is directed at the use of organo-substituted nitrogen oxides, particularly amine oxides for rust inhibition and as anti-icing agents in gasoline. Several representative formulas for amine oxides are given including the following:



$$R_1 - \overset{\displaystyle R_2}{\underset{\displaystyle R_3}{N}} \rightarrow O$$

where: R_1 is C_6-C_{24} alkyl, aryl, cycloaliphatic, heterocyclic, substituted alkyl or substituted aryl; and R_2 and R_3 are the same or different and are C_1-C_{24} alkyl, aryl, substituted alkyl or aryl, cycloaliphatic or heterocylic. R_2 and R_3 preferably comprise hydroxy substituted alkyls. These compounds typically are added to gasoline in a concentration within the range of about 2.0 to about 100 pounds of amine oxide per 1,000 barrels of gasoline (ptb). Among the most preferred additives is bis(2-hydroxy ethyl) cocoamine oxide.

U.S. Patent No. 3,594,139 is directed at a rust-inhibitor concentrate that can be blended with gasoline year-round including amine oxides having the aforementioned formula, with a particularly preferred amine oxide comprising bis(2-hydroxy ethyl) cocoamine oxide. The concentrate also comprises a liquid aromatic C_7-C_{10} hydrocarbon and an aliphatic monohydric or dihydric alcohol having from about 6 to about 13 carbon atoms. Preferred aromatic hydrocarbons comprise ortho, meta and mixed xylenes. Preferred aliphatic alcohols comprise C_6-C_{13} oxo alcohols. The examples disclose the combination of xylene, bis(2 hydroxyethyl) cocoamine oxide, and C_8 oxo alcohols.

The amine oxides described above have been typically used to inhibit rust and carburetor icing. While these compounds were used commercially during the late 1960's and early 1970's, their use in the United States was discontinued as more effective additives were found. The use of these compounds had been discontinued in the United States well before the development of electronically controlled, fuel injected engines.

It has been discovered that use of amine oxides at concentrations generally higher than that which previously had been used for rust inhibition would be effective in preventing and/or reducing injector fouling in multiport fuel injected engines. However, when amine oxides are used at these higher concentrations they tend to act as emulsifiers which bring into the gasoline layer, water, sediment and impurities which may have entered the product distribution system. This prevents normal separation of the gasoline from any water or normally insoluble impurities. The admixture of these impurities is not desired with the gasoline, since this would result in excessive fuel filter fouling and in poor vehicle operation. In addition, it is believed that formation of an emulsion results in undesirable concentration of the amine oxide additive at the interface. It also has been found that the use of certain solvents to produce an additive concentrate having low cloud and pour points may form two organic layers, resulting in uneven additive distribution.

Accordingly, it would be desirable to provide an additive package for gasoline which will be effective in reducing and/or eliminating fouling without forming an emulsion with water bottoms and interfacial solids.

It also would be desirable to provide an additive package having a demulsifying agent which is effective in the presence of both neutral and basic waters.

It also would be desirable to provide an additive concentrate which has low cloud and pour points and which does not result in the formation of more than one organic layer.

Accordingly, it would be desirable to provide a gasoline additive package which is relatively inexpensive and effective at low concentrations to reduce and/or eliminate injector fouling.

It also would be desirable to provide a gasoline additive package which is non-corrosive, nondeleterious to the catalyst, and does not effect the combustion characteristics of the fuel.

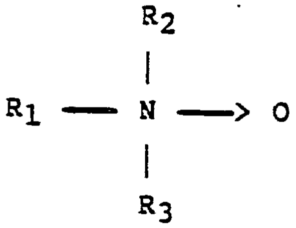
It also would be desirable to provide a gasoline additive package which could be easily added to the finished gasoline at any point during the storage and/or distribution system.

SUMMARY OF THE INVENTION

The present invention is directed at a fuel composition for minimizing and/or preventing injector fouling in a multiport electronically controlled fuel injected engine. The composition comprises:

A. gasoline

B. an anti-fouling agent having the formula:



$$R_1 - \overset{\displaystyle R_2}{\underset{\displaystyle R_3}{N}} \longrightarrow O$$

where: R_1 is C_6-C_{24} alkyl, aryl, cycloaliphatic, heterocyclic, substituted alkyl or substituted aryl; and R_2 and R_3 independently are C_1-C_{24} alkyl, aryl, substituted alkyl or aryl, cycloaliphatic or heterocylic; and,

C. a demulsifier comprising one or more of the following demulsifying agents:

i. a fatty acid alkylamine reaction product; and,

ii. a solution of oxyalkylated alkyl phenol formaldehyde resins and polyglycols.

In this composition R_1 preferably is C_6-C_{20} alkyl, or alkylated aryl, and R_2 and R_3 independently are C_1-C_{12} hydroxy substituted alkyl. In a more preferred composition R_1, comprises C_8-C_{18} substituents derived from fatty acid. The additive preferably is selected from the group consisting of bis(2-hydroxy ethyl) cocoamine oxide, bis(2-hydroxy ethyl) tallow amine oxide, bis(2-hydroxy ethyl) stearyl-amine oxide, dimethylcocoamine oxide, dimethyl hydrogenated tallow amine oxide, dimethylhexadecylamine oxide and mixtures thereof. A particularly preferred additive is bis(2-hydroxy ethyl) cocoamine oxide. The anti-fouling agent concentration in the fuel typically may range between about 0.5 and about 50 ptb (i.e. about 2 to about 200 ppm, by weight), preferably between about 5 and about I5 ptb (i.e. about 20 to about 60 ppm).

In demulsifying agent (ii) the oxyalkylated compounds preferably comprise ethylene oxide and propylene oxide copolymers. The active concentration of the demulsifying agent may range between about 0.025 and about I0 ptb (about 0.I and about 40 ppm), preferably between about 0.25 and about 2.0 ptb - (about I.0 and 8.0 ppm).

A fuel composition may comprise:

A. about 2 to about 200 ppm bis(2-hydroxy ethyl) cocoamine oxide; and,

B. about 0.I to about 40 ppm of a demulsifying agent selected from the group consisting of:

i. fatty acid alkylamine reaction product;

ii. a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols; and mixtures of i and ii.

A preferred composition comprises:

A. about 20 to about 60 ppm bis(2-hydroxy ethyl) cocoamine oxide; and,

B. about I to about 8 ppm of a demulsifying agent selected from the group consisting of:

i. fatty acid alkylamine reaction product;

ii. a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols; and mixtures of i and ii.

A preferred fuel composition includes an additive package comprising:

A. about 20 ppm to about 60 ppm bis(2-hydroxy ethyl) cocoamine oxide;

B. about 0.5 ppm to about 4 ppm fatty acid alkylamine reaction product; and,

C. about 0.5 ppm to about 4 ppm of a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols.

The present invention also is directed at a fuel additive concentrate for internal combustion engines, said additive concentrate comprising:

A. about 5 to about 50 wt.% bis(2-hydroxy ethyl) cocoamine oxide;

B. about 0.25 to about I0 wt.% of a demulsifying agent selected from the group consisting of:

i. fatty acid alkylamine reaction product;

ii. a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols; and mixtures of i and ii; and,

C. about 40 to about 95 wt.% solvent.

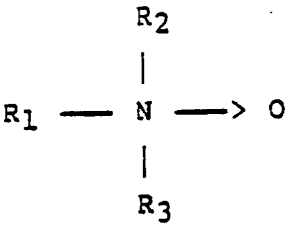
The solvent preferably comprises xylene and a C_4+ alcohol, preferably a C_4-C_{12} alcohol, more preferably a C_8 alcohol and most preferably a C_8 oxo alcohol. Where the ratio of the concentration of water relative to amine oxide exceeds about 0.05, a highly water and hydrocarbon soluble alcohol, preferably isopropanol, also should be added.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed at a fuel composition and a gasoline additive package which has been found to be particularly effective in reducing and/or eliminating injector fouling. The present invention is directed at a fuel comprising:

A. gasoline;

B. an anti-fouling agent having the following structural formula:



$$R_1 \longrightarrow \overset{\displaystyle R_2}{\underset{\displaystyle R_3}{N}} \longrightarrow O$$

where R_1 is C_6-C_{24} alkyl, aryl, cycloaliphatic, heterocyclic, substituted alkyl, substituted aryl; R_2 and R_3 independently are C_1-C_{24} alkyl, aryl, substituted alkyl or aryl, cycloaliphatic, heterocyclic, and mixtures thereof; and,

C. a demulsifying agent selected from the group consisting of:

i. a fatty acid alkylamine reaction product;

ii. a solution of an oxyalkylated alkylphenol formaldehyde resins and polyglycols; and mixtures thereof.

Preferred anti-fouling agents include compounds wherein: R_1 is C_6-C_{20} alkyl, or alkylated aryl; and R_2 and R_3 independently are hydroxy substituted C_1-C_{12} alkyl. Particularly preferred compounds are compounds wherein R_1 comprises a C_8-C_{18} substituent. The additive preferably is selected from the group consisting of bis (2-hydroxy ethyl) cocoamine oxide, bis(2-hydroxy ethyl) stearylamine oxide dimethylcocoamine oxide, dimethyl hydrogenated tallow amine oxide, dimethylhexadecylamine oxide and mixtures thereof. These additives are prepared in accordance with known techniques, such as disclosed in U.S. Patent 3,387,953, the disclosure of which is incorporated herein by reference. A particularly preferred anti-fouling agent is bis(2-hydroxy ethyl) cocoamine oxide.

The following Comparative Examples and Examples demonstrate the utility of the anti-fouling agent in reducing and/or eliminating fuel injector fouling. In the following Comparative Examples and Examples, the octane rating of the fuel utilized is the posted octane rating which is defined as:

$$\frac{\text{Research Octane} + \text{Motor Octane}}{2}$$

COMPARATIVE EXAMPLE I

In this test three 1985 Oldsmobile 98's having electronically controlled, fuel injected, 3.8 liter, six cylinder engines were driven on a commercial, unleaded, 87 octane reference fuel having a detergent concentration of 8.5 ptb for approximately 3500 miles under the following driving cycle: 0.5 hours city-type driving, 0.5 hour engine off, 0.5 hour highway driving, 0.5 hour engine off. Driveability on all four vehicles became poor to very poor. The vehicles then were driven for 300 miles with a commercial premium grade 92 octane unleaded fuel containing 2.5 times the detergent used in the above reference fuel. Driveability remained unchanged. The data in Table I below show that there was still a marked reduction in fuel flow indicating that a high level of deposit was unaffected by the detergent even at the high treat rate. The percent fuel flow reduction was determined by measuring the volume of a mineral spirit that flowed through the injector under predetermined standardized conditions, including fuel pressure, pulse width and duty cycle. The percent reduction is calculated using the formula:

$$\%\ \text{Reduction} = \frac{V_{clean} - V_{dirty}}{V_{clean}} \times 100\%$$

where V_{clean} and V_{dirty} are the measured volumes of mineral spirit passed through the clean and dirty fuel injectors.

TABLE I

% FLOW REDUCTION THROUGH INJECTOR PORTS

Cyl #	1	2	3	4	5	6
Car A	11	12	35	30	7	10
Car B	7	9	12	38	9	14
Car C	22	11	28	4	11	10
Typical New Injectors	2	2	0	0	2	1

From Table I it can be seen that this conventional, known carburetor detergent was ineffective in removing deposits from injector ports and in fact permitted deposits to form.

COMPARATIVE EXAMPLE II

A 1985 Chrysler LeBaron equipped with a 2.2 liter turbocharged engine having electronically controlled fuel injection was driven for 1300 miles on a mileage accumulation dynamometer using a typical regular grade, 87 octane, unleaded, detergent-free gasoline. The driving was based on repetition of the following cycle: 30 minutes city driving, 30 minutes engine off, 30 minutes highway driving, 30 minutes engine off. The driveability became very poor as typified by rough idle and severe hesitation. The hydrocarbon emissions measured before the catalytic converter were 321 ppm at engine idle. The injector fouling was measured using a pressure differential test. In this test the fuel rail is pressurized to 49 psig and an injector is pulsed for 0.5 seconds. The pressure drop, or leakdown P, is indicative of how readily the fuel flows, i.e., the higher the number, the less the injector is obstructed. In this vehicle the pressure differential for a clean injector under these conditions is 19-22 psig. This data is set forth below in Table II.

EXAMPLE I

Following the test set forth in comparative Example II, the vehicle was refueled with the same fuel except that the fuel also contained I0 ptb of bis(2-hydroxy ethyl) cocoamine oxide (HECO). The vehicle then was driven on the following cycle: I5 minutes city driving, 30 minutes highway driving, I5 minutes city driving, 2 hours engine off. This test continued until 270 miles were accumulated on the vehicle. At the end of this test period the driveability was very good. The hydrocarbon emissions at idle before the catalytic converter were reduced to 200 ppm. The percent injector flow reduction and the pressure differential were significantly improved as set forth in Table II.

From the data of Example I and Table II it can be seen that the use of a relatively low concentration of HECO was able to produce a significant improvement in driveability. The idle emissions were significantly reduced and the pressure differential and percent flow reduction of the flow injectors were returned to "as new" conditions after a relatively few miles of driving.

TABLE II

PORT INJECTOR FOULING

HECO ADDITIVE CONCENTRATION (ptb)	MILES DRIVEN		% INJECTOR FLOW REDUCTION					Δ LEAKDOWN ΔP			
		INJECTOR NO.	1	2	3	4	INJECTOR NO.	1	2	3	4
None	1300		Not run*					13	13	13	12
10	270		0	1	0	0		19	19	19	19

* Test not run to avoid disturbing deposit formation before end of test.

As shown by the following Comparative Examples and Example, bis (2-hydroxy ethyl) cocoamine oxide also was effective in preventing the build-up of fuel injector tip deposits.

COMPARATIVE EXAMPLE III

In this Comparative Example, four 1985 Chrysler LeBarons equipped with four cylinder, electronically controlled, fuel injected, turbocharged, 2.2 liter engines were driven on mileage accumulation dynamometers under the following conditions: 0.5 hour city-type driving, 0.5 hour engine off, 0.5 hour highway type driving and 0.5 hour engine off for 4,000 miles. The control cars ran on a regular grade, 87 octane, detergent-free, unleaded fuel. Following the test, the percent flow reduction was measured using the procedures previously set forth hereinabove. The tests were repeated in four different runs (same make and model). The results of these tests are set forth in Table III below.

EXAMPLE II

A 1985 Chrysler LeBaron, similar to that set forth in Comparative Example III was used in this test which was conducted under the same conditions set forth in that Comparative Example. The gasoline used during this test was the same as that used in the control cars, but with the further addition of 10 ptb of bis(2-hydroxy ethyl) cocoamine oxide (HECO). The results of these tests are also set forth in Table III below. From a review of these tests it can be seen that the addition of a relatively low concentration of HECO was able to prevent a significant reduction in the fuel injector flow rate.

TABLE III

HECO ADDITION PREVENTS SIGNIFICANT INJECTOR PORT FOULING

	Initial Test						Repeat Test	
Comp. Example III	Driveability	% Flow Reduction #1	#2	#3	#4	Avg.	Driveability	Avg. % Flow Reduction
Control Car No.								
1	Undriveable	35	25	24	24	24	Undriveable	26
2	Undriveable	39	13	14	16	20	Undriveable	19
3	No problems	13	23	13	14	16	Undriveable	19
4	Undriveable	3	21	11	14	12	Undriveable	11
Example II								
Car with HECO in fuel	No problems	0	0	0	0	0	No problems	<1.0*

* Car run 5,000 miles

COMPARATIVE EXAMPLE IV

In this test a 1985 Chrysler LeBaron having a four cylinder, turbocharged, 2.2 liter engine with electronically controlled fuel injection was operated for 2,002 miles on a mileage accumulation dynamometer simulating alternating driving and engine-off cycles. The fuel utilized was typical of a regular grade, 87 octane, unleaded fuel containing 8.5 ptb of the same detergent used in Comparative Example I. Following the completion of this test, the percent flow reduction through the fuel injector ports was measured by the method previously described herein. As shown in Table IV below the use of this conventional carburetor detergent was ineffective in preventing injector fouling.

EXAMPLE III

A vehicle similar to that utilized in Comparative Example IV was utilized in this Example under the same operating conditions. The fuel utilized was similar but with the replacement of the conventional carburetor detergent by 10 ptb of bis(2-hydroxyl ethyl) cocoamine oxide. The vehicle was driven for 9,600 miles under the same sequence set forth in Comparative Example IV. The bis(2-hydroxy ethyl) cocoamine oxide was able to prevent any significant flow reduction in the fuel injectors as shown by data presented in Table IV.

TABLE IV

COMPARISON OF HECO AND CONVENTIONAL CARBURETOR DETERGENT IN PREVENTING INJECTOR PORT FOULING

ADDITIVE	CONCENTRATION, ptb	MILES DRIVEN	CYL #	% FLOW REDUCTION 1	2	3	4
Conventional Carburetor Detergent	8.5	2,002		4	8	1	16
HECO	10	9,600		0	1	0	0

From this Table it can be seen that the use of a relatively low concentration of HECO was able to prevent any significant buildup of injector tip deposits. By comparison, the use of a conventional carburetor detergent at approximately the same rate was unable to prevent a relatively rapid deposit buildup of injector tip deposits.

While the data presented above has demonstrated the utility of the anti-fouling agent in gasoline, the anti-fouling agent also may be of utility in other fuels, such as diesel fuel.

While the presently described anti-fouling agent may be used alone, it also may be desirable to utilize the present invention in combination with a demulsifier to facilitate the separation of the gasoline from any foreign substances which may be present in the distribution system, such as water and sediment.

The water, if any, typically has a pH ranging from about 7 to about 12. Thus, a demulsifier for use with the anti-fouling agent preferably should be effective over this pH range. The following Comparative Examples and Examples demonstrate the utility of a demulsifying agent selected from the group consisting of:

A. a fatty acid alkylamine reaction product;

B. a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols; and mixtures of A and B above.

COMPARATIVE EXAMPLE V

In this Comparative Example the effectiveness of various commercially available demulsifying agents were tested in a 90 wt.% fuel -10 wt.% water system. The fuel contained 10 ptb HECO and 1 ptb of the various additives noted below. The effectiveness of the various demulsifying agents was reached using a Multiple Contact Emulsion Test. In this test 10 ml of distilled water was added to separate half-pint bottles. To each bottle was added 100 ml of gasoline. The bottles were capped, placed on their sides in a mechanical shaker and agitated at approximately 28 cycles per minute for five minutes. The bottles then were placed upright in a dark location and allowed to stand for 24 hours. The mixture then was rated considering the gasoline layer, the water layer and the interface using the rating scale set forth in Table V below. After the ratings were completed, the gasoline level was sucked down to a level about 1/4 inch above the emulsion layer without disturbing the interface or water layer. The withdrawn fuel was discarded and 100 ml of fresh gasoline was added to each bottle. The mixture was then shaken and the test repeated for a total of ten times (i.e. a total of about 10 days) or until it became apparent that the emulsion forming tendencies had exceeded acceptable levels of 3 or lower. The trade names of the commercially available additive utilized, the worst ratings of each mixture and the time period before each test was terminated are set forth in Table VI below.

TABLE V

RATING SCALE FOR REPORTING EMULSION TEST REUSLTS

RATING	DESCRIPTION OF EMULSION
0	No skin or interface
1	Slight skin on interface - not completely continuous
2	Thicker skin on interface - usually completely continous
3	Incipient emulsion 1/8 as thick as water layer
4	Emulsion 1/4 as thick as water layer
5	Emulsion 3/8 as thick as water layer
6	Emulsion 1/2 as thick as water layer
7	Emulsion 5/8 as thick as water layer
8	Emulsion 3/4 as thick as water layer
9	Emulsion 7/8 as thick as water layer
10	Emulsion completely filling water layer Emulsion of maximum severity

TABLE VI

EMULSION TEST RESULTS

DEMULSIFIER DESCRIPTION	WORST RATING	DAYS RUN
None	6	10
Tolad		
T-284	5	4
T-286	4	3
T-292	4-5	5
T-347	4-5	3
T-370	5	6
T-500	3-4	6
T-364	6	4
Nalco		
5450	6	3
5451	4	5
5452	5	5
5453	4	6
5455	4-5	5
5RD646	6	6
5RD649	6	6
5RD651	4	8
5RD652	6	6
5RD653	6	6
5RD654	6	6
5 or 6RD871	7	6
85BD194	4	5

EXAMPLE IV

A gasoline-distilled water sample having I0 ptb of HECO similar to that of Comparative Example V was utilized. However, in place of the demulsifiers listed in Table VI the following additives were used alone or in combination.

Additive A -Nalco 3BD829 Fuel Dehazer, manufactured by Nalco Chemical Company, Oak Brook, Illinois, which comprises a fatty acid alkylamine reaction product and methanol in a hydrocarbon solvent.

Additive B -Tolad T-326 manufactured by the Tretolite Division of Petrolite Corporation, St. Louis, Missouri. This additive comprises oxyalkylated alkylphenol-formaldehyde resins and polyglycols in aromatic naphtha. The Multiple Contact Emulsion Test previously described was utilized to determine the effectiveness of these demulsifiers. These test results are summarized in Table VII below.

TABLE VII

EMULSION TEST RESULTS

DEMULSIFIER DESCRIPTION	CONCENTRATION	WORST RATING	DAYS RUN
Additive A	1 ptb	0	10
Additive B	1 ptb	2	10
Additive A	0.5 ptb	0	10
Additive B	0.5 ptb		

From a review of Table VII, it can be seen that both Additive A and Additive B were effective. It also can be seen that Additive A and the same total concentration of a mixture of Additive A and Additive B were more effective than Additive B alone.

EXAMPLE V

A sample comprising 100 ml portions of gasoline containing 10 ptb of HECO and a total of 1 ptb of Additive A, Additive B or a combination of Additive A and Additive B was tested with another typical gasoline contaminant, refinery process water bottoms having a pH of 10. A sample containing 90 wt.% of this fuel and 10 wt.% of the process water bottoms was utilized. The Multiple Contact Emulsion Test described in Comparative Example V was utilized with one modification. The sample was shaken at 1 1/2 hour intervals rather than 24 hour intervals. Thus, this procedure is more severe than the test method of Comparative Example V. The results of this test are set forth in Table VIII below.

TABLE VIII

MODIFIED EMULSION TEST RESULTS

DEMULSIFIER DESCRIPTION	CONCENTRATION	WORST RATING	NUMBER OF GASOLINE TREATS
Additive A	1 ptb	7	10
Additive B	1 ptb	2	10
Additive A	0.5 ptb	2	10
Additive B	0.5 ptb		

From this table it can be seen that Additive B and a mixture of Additive A and Additive B were more effective than Additive A alone.

Demulsifier Additive A was thus found to be more effective than Additive B with neutral water, while Additive B was much more effective than Additive A when the water was basic. The combination of these additives is particularly preferred, since it was highly effective in both neutral and basic conditions.

Where the presently described invention is used as a gasoline additive, the additive package may be added to the gasoline at any point after the gasoline has been refined, i.e., the additive package can be added at the refinery or in the distribution system. To assure a relatively constant concentration of the additive package in the gasoline and to assure that none of the additives precipitate from the additive package, diluent solvents typically are combined with the additive package to produce an additive concentrate which is metered into the fuel.

The amine oxide typically has water present from the manufacturing process. While it is possible to remove most of the water, removal of the water to relatively low levels, i.e. a ratio of about 0.02 to about 0.04 of water to amine oxide, adds complexity to the manufacturing process. Therefore, the amine oxide is commercially available as a solution which has the following composition:

Additive	Approximate Concentration, Wt.%
HECO	47-49
isopropyl alcohol	45
water	6-8

To provide an additive concentrate which is pumpable and which does not precipitate even in winter conditions, the concentrate preferably should have a cloud point below about -20°F and a pour point of less than -40°F.

Typically, the additive package is diluted in the range of about 1:1 to about 10:1 with diluent solvent, preferably about 5:1 to facilitate metering and to provide a concentrate having the desired cloud and pour points.

COMPARATIVE EXAMPLE VI

In this test, the additive package was diluted about 4.9:1 with a diluent which comprised about 90 wt.% xylene and 10 wt.% isopropanol. The resulting concentrate had the following composition:

Additive	Approximate Concentration, Wt.%
Amine Oxide	8.00
Xylene	73.50
isopropyl alcohol	15.84
water	1.00
Demulsifier A	0.83
Demulsifier B	0.83
	100.00

Twenty-five ml. of this additive concentrate were mixed with 25 ml. of gasoline and 10 ml. of refinery water bottoms in an 8 inch centrifuge tube with a narrow tip to simulate the conditions which could occur in the field before the additive concentrate is completely mixed with the gasoline. An excess of water was included for illustrative purposes as set forth below.

The tube was placed in an ultrasonic bath at room temperature and subjected to ultrasonic frequencies for about five minutes to cause intimate mixing. After removal from the ultrasonic bath and centrifugation to facilitate separation, it was noted that three phases had formed, two organic phases and a water phase. Formation of two organic phases is not desirable, since this was found to result in uneven distribution of the HECO between the layers. In addition, the second organic layer which has a much higher HECO concentration, tends to adhere to the surfaces, resulting in additive loss and potential contamination of subsequent hydrocarbon products that might contact these surfaces.

EXAMPLE VI

In this Example, the same additive package was used as was used in Comparative Example VI. The additive package again was diluted with about 4.9 parts solvent. However, in this Example the isopropanol in the diluent solvent was replaced with an equal weight of C_8 oxo alcohol. The concentrate had the following composition:

Additive	Approximate Concentration, Wt.%
Amine Oxide	8.00
Xylene	73.50
C_8 oxo alcohol	8.17
isopropyl alcohol	7.67
water	1.00
Demulsifier A	0.83
Demulsifier B	0.83
	100.00

Twenty-five ml. of this additive concentrate were mixed with 25 ml. of gasoline and 10 ml. of refinery water bottoms and intimately mixed in an ultrasonic bath as described in Comparative Example VI. After intimate mixing and centrifugation to facilitate separation, it was noted that only two layers, an organic layer and a water layer were formed.

From this Example it can be seen that the replacement of at least a portion of the isopropanol by a higher molecular weight alcohol, preferably a C_4-C_{12} alcohol, more preferably an oxo alcohol and most preferably a C_8 oxo alcohol, prevented the formation of two organic layers. As used herein the term "oxo alcohol" refers to one or more branched chain aliphatic alcohols prepared by the reaction of carbon monoxide and olefins followed by hydrogenation of the resulting aldehydes.

A series of tests also were run utilizing different solvents to determine the cloud point of the resulting additive concentrates. Those tests generally were conducted in accordance with ASTM test method D2500, the disclosure of which is incorporated herein by reference. These results are presented in Table IX.

TABLE IX

CLOUD POINT DETERMINATIONS

Additive Concentrate Composition, Wt.%						
Solvent Composition						
Xylene	Isopropanol	C_8 Oxo Alcohol	Amine Oxide	Water	Demulsifier	Cloud Point, °F
81.67	7.67	0	8.00	1.00	1.66	-36
73.50	7.67	8.17	8.00	1.00	1.66	<-46
73.50	15.84	0	8.00	1.00	1.66	<-50
81.67	0	7.67	8.00	1.00	1.66	Cloudy at room temperature
79.22	0	10.12	8.00	1.00	1.66	+8
77.59	0	11.75	8.00	1.00	1.66	-18
75.95	0	13.39	8.00	1.00	1.66	-30
73.50	0	15.84	8.00	1.00	1.66	Cloudy at room temperature

From a review of Table IX, it can be seen that the combination of a solvent system comprising xylene, isopropyl alcohol and C_8 oxo alcohol produces an additive concentrate which has a cloud point below about -46°F for the point tested. By comparison, use of a solvent system comprising only xylene and C_8 oxo alcohol produced a system which had acceptable cloud points only over a very narrow concentration range. Therefore, the use of a mixed alcohol solvent system is desirable to produce a concentrate having good low temperature properties without the tendency to form a second organic layer.

Multiple Contact Emulsion Tests were conducted in a manner similar to that set forth in Comparative Example V for gasoline samples. The tests were run on both unleaded regular grade gasoline and unleaded premium grade gasoline containing 10 ptb HECO and 0.5 ptb each of Demulsifiers A and B, to which 10 wt.% terminal water bottoms having a pH of about 7 and 8, respectively, had been added as previously described. The samples were shaken for 10 minutes at 180 cycles per minute. The bottles then were permitted to stand for the times indicated and rated. As shown by the data in Table X, the replacement of the isopropanol by the combination of isopropanol with C_8 oxo alcohol did not adversely affect the effectiveness of the demulsifier package. Thus, a concentrate including a solvent system comprising isopropanol and C_8 oxo alcohol has acceptable demulsifying properties and an improved cloud point relative to a solvent system comprising C_8 oxo alcohol alone, when significant quantities of water are present. As previously noted, such a solvent system also does not promote the formation of multiple organic layers.

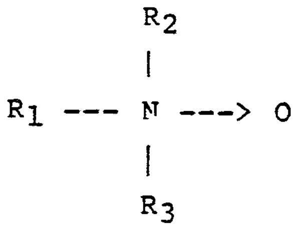
TABLE X

MULTIPLE CONTACT EMULSION TEST

Fuel	Time (Hrs.)	Emulsion Rating	
		Isopropanol Alone	Isopropanol + C8 oxo Alcohol
Unleaded Regular	1	2	2
	4	2	2
	24	2	2
Unleaded Premium	1	3	2-3
	4	2-3	2-3
	24	2	2

Claims

1. A fuel composition for an internal combustion engine said engine composition comprising:
   A. gasoline;
   B. an antifouling agent having the formula



$$R_1 \text{ --- } \overset{\displaystyle R_2}{\underset{\displaystyle R_3}{N}} \text{ ---> } O$$

wherein: R_1 is C_6 to C_{24} alkyl, aryl, cycloaliphatic, heterocyclic, substituted alkyl or substituted aryl; R_2 and R_3 independently are C_1 to C_{24} alkyl, aryl, substituted alkyl or aryl, cycloaliphatic or heterocyclic; and

C. a demulsifier selected from the group consisting of:

i. a fatty acid alkylamine reaction product;

ii. a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols; and mixtures of i and ii.

2. The fuel composition of claim l wherein R_1 is C_6 to C_{20} alkyl, or alkylated aryl; and, R_2 and R_3 independently are hydroxy substituted C_1 to C_{12} alkyl.

3. The fuel composition of claim 2 wherein the fuel comprises unleaded gasoline.

4. The fuel composition of claim 3 wherein the demulsifier comprises:

A. a fatty acid alkylamine reaction product; and,

B. a solution of oxyalkylated alkylphenol formaldehyde resins and polyglycols.

5. A fuel additive concentrate for internal combustion engines, said additive comprising:

A. about 5 to about 50 wt.% bis(2-hydroxy ethyl) cocoamine oxide;

B. about 0.25 to about l0 wt.% fatty acid alkylamine reaction product; and,

C. about 0.25 to about l0 wt.% oxyalkylated alkylphenol formaldehyde resins and polyglycols;

D. about 40 to about 95 wt.% solvent.

6. The fuel additive concentrate of claim 5 wherein the solvent comprises xylene and an alcohol.

7. The fuel additive concentrate of claim 6 wherein the alcohol is selected from the group consisting of isopropanol, C_4-C_{12} alcohols, and mixtures thereof.

8. A fuel additive concentrate for internal combustion engines, said additive comprising:

A. about 5 to about 50 wt.% bis(2-hydroxy ehtyl) cocoamine oxide;

B. about 0.25 to about l0 wt.% of a demulsifying agent; and,

C. about 40 to about 95 wt.% of a solvent comprising:

i. xylene; and

ii. a C_4-C_{12} alcohol.

9. The fuel additive of claim 8 wherein the solvent further comprises isopropanol.

l0. A fuel composition for reducing and/or preventing fouling in a multiport electronically controlled fuel injection system for an internal combustion engine, said fuel composition comprising:

A. about 20 to about 60 ppm bis(2-hydroxy ethyl) cocoamine oxide;

B. about 0.5 to about 4 ppm fatty acid alkylamine reaction product; and,

C. about 0.5 to about 4 ppm oxyalkylated alkylphenol formaldehyde resins and polyglycols.

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 87 30 0738

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	US-A-3 594 139 (BOUFFARD) * Whole document *	1,2,5-8	C 10 L 1/14 C 10 L 10/00 C 10 L 1/22 F 02 B 77/04
A		3,4,9,10	

Y	US-A-3 909 215 (KRAY) * Whole document *	1,2,5-8	
A		3,4,9,10	

A	GB-A-1 153 024 (ESSO) * Whole document *	1-10	
	---		**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
A	US-A-3 007 784 (EBNER) * Whole document *	1-10	C 10 L F 02 B

A	GB-A- 842 991 (DU PONT DE NEMOURS) * Claim 8 *	1,4,5,8,10	

A	US-A-4 482 356 (HANLON) * Whole document *	10	
	--- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	06-05-1987	DE LA MORINERIE B.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	US-A-3 468 639 (LINDSTROM et al.) * Claims; page 1; column 6 * ---	1-10	
A	DE-A-1 900 531 (BURLANDO et al.) * Whole document * ---	1,4,5 8,10	
A	FR-A-1 381 443 (NALCO) * Whole document * ---	1,4,5 8,10	
A	US-A-3 251 664 (DICKSON et al.) * Whole document * -----	1,4,5 8,10	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)

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