United States Patent Office 3,116,128
Patented Dec. 31, 1963

3,116,128

FUEL OIL COMPOSITION AND COMPOSITE IMPROVEMENT AGENT THEREFOR

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No Drawing. Filed Dec. 28, 1959, Ser. No. 862,040
11 Claims. (Cl. 44—71)

This invention relates to improving the combustion characteristics of hydrocarbon oil fuels that normally tend to form substantial amounts of soot and smoke during combustion, and to improvement agents adapted for use in such fuels.

The petroleum industry has encountered a serious problem in satisfying the demand for middle distillate and heavier fuel oils that can be burned in fuel burners, such as those of the atomizing type and of the rotary wall flame type, with little or no accompanying formation of smoke or soot. Oils that are normally burned in oil burners of the types indicated are those of No. 2 grade or heavier, although somewhat lighter oils can be used. Although some smoke and soot formation may accompany combustion of any hydrocarbon oil where less than optimum combustion conditions are used, the problem is serious in the case of oils having an API gravity of less than 34°, as substantial smoking and soot formation will occur during combustion of such oils even when favorable combustion conditions are employed. The poor combustion characteristics of such oils are considered attributable to the relatively high proportion of aromatic components contained therein. Fuel oils having an API gravity of less than 34° will normally contain in excess of about 20 percent aromatics, for example, 25, 40, or even 60 percent or more of aromatic components, whereas lighter fuel oils will normally contain a substantially lower proportion of aromatics, for example, 15 percent or less. In the case of distillate oils, a high aromatics content usually signifies a large proportion of cracked distillates, as the latter are relatively rich in aromatics. The proportion of catalytically cracked distillate fuel oils in commercially marketed fuel oils has increased in recent years notwithstanding the relatively inferior burning qualities of such oils, because the demand for fuel oils of comparable boiling range has exceeded the available supply of straight-run oils.

Not only do low API gravity distillate oils containing large proportions of cracked distillate, that is, oils rich in aromatics, form greater quantities of soot during combustion than straight-run, high API gravity distillate oils, or similar oils low in aromatics, but also such oils form soot of different quality. Soot formed from the latter oils is a loosely deposited, low-density material having a low coefficient of heat transfer, whereas soot from the former oils is resinous, much denser and has a higher coefficient of heat transfer.

While the problem of obtaining clean combustion is especially serious in the case of distillate fuels, where fuel quality is of major importance, a combustion problem also exists in the case of residual fuel oils. Residual fuels, similarly as middle distillate fuel oils, have an API gravity less than 34° (API gravity for typical No. 6 fuel oils varies in the range of about 5° to 15°), and they also frequently contain exceptionally large proportions, for example 60 percent or more, of aromatic components. Residual fuels can contain relatively low-boiling aromatic components as well as higher boiling materials, as they are frequently diluted or cut back with lower boiling cracked distillate oils in order to reduce the viscosity of the heavier oils.

Although the combustion of fuel oils having an API gravity of less than 34°, and consequently a relatively large proportion of aromatics, will tend to produce soot and smoke in atomizing-type burners, that is, burners in which the fuel oil is burned in the form of a spray of liquid droplets after mixture with air, combustion of such oils in rotary wall-flame type burners constitutes an especially severe problem. In the latter instance the fuel oil is burned in vapor form after vaporization of the fuel by impingement thereof on a hot metal surface.

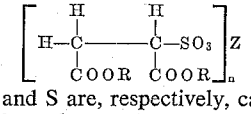
Excessive smoking and soot formation during combustion of fuel oils is objectionable not only from the standpoint of cleanliness and air pollution, but also in that smoke and soot lead to stack deposits which may reduce burner draft and/or cause the stack temperature to rise to a dangerous point.

The present invention relates to improvement of hydrocarbon fuel oils that normally exhibit smoke and soot-forming tendencies during combustion, whereby such oils are rendered more suitable for use as fuels in domestic oil burners of various types such as heating furnaces of the atomizing or rotary wall-flame type, combustion gas turbine engines, diesel engines, and the like. We have found that such improved fuel compositions can be obtained by incorporating in a fuel oil that normally tends to form substantial smoke and soot during combustion about 0.005 to about 2 percent, preferably about 0.02 to 0.05 percent by weight of a combination of (*a*) a preferentially oil-soluble secondary or tertiary amine at least one of whose N-substituents is an open-chain or cyclic, saturated or unsaturated aliphatic hydrocarbon substituent or an aromatic hydrocarbon substituent, including alkaryl and aralkyl, containing 6 to 22 carbon atoms, preferably 8 to 18 carbon atoms, another of whose N-substituents is an aliphatic hydrocarbon radical that contains 1 to 22 carbon atoms and that is either saturated or unsaturated and either unsubstituted or substituted with nonhydrocarbon substituents such as hydroxyl, amino, or halogen, or the like, and whose remaining N-substituent is either hydrogen or a substituent of the same class as either of the previously described N-substituents, and (*b*) an alkali metal, alkaline earth metal, ammonium or ethylolammonium dialkylsulfosuccinate whose alkyl groups each contain 7 to 9 carbon atoms, at least 6 of which are in a straight chain, but there being no group containing more than 7 carbon atoms attached to the alpha-carbon atom of said alkyl groups. Insofar as the amine component is concerned, amines containing secondary amino groups are considered especially effective, a preferred example being 3-dodecylaminopropylamine. An example of a preferred tertiary amine is N,N-di-n-propylaniline. However, other secondary and tertiary amines of the class indicated can be used. The dioctylsulfosuccinates are especially valuable dialkylsulfosuccinates for the purposes of this invention, sodium di(2-ethylhexyl)sulfosuccinate being an example of a preferred salt. However, the use of other dialkylsulfosuccinates within the class disclosed is included by the present invention. The amines and the dialkylsulfosuccinates can be employed in fuel oils in varying proportions with respect to each other provided that each is present in an amount of at least 0.0025 percent and preferably 0.005 to 0.05 percent by weight of the oil, but larger amounts of each can be used. The present invention includes not only the compounded fuel oils containing the above-indicated combination of improvement agents, but also the combination of improvement agents, as such. In such form we normally prefer to employ the respective components of the combination in a weight ratio of about 1:20 to 20:1, and more preferably about 1:5 to 5:1. However, other proportions can be used.

The exact mechanism by which the combination of improvement agents of the above-indicated classes functions to reduce smoke- and soot-forming tendencies of

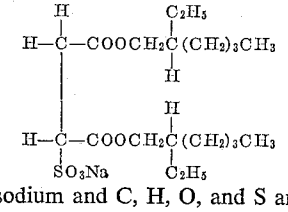
fuel oils has not been definitely determined, and accordingly, we do not intend the present invention to be limited to any particular theory of operation. It may be that the combination of improvement agents disclosed herein reduce smoke and soot formation at least in part by reducing the ignition temperature of the oil, whereby more complete combustion of the oil may be obtained, and whereby at the same time the possibility of thermal cracking of the fuel oil prior to combustion is reduced. The above-indicated mechanism is more or less suggested by the fact that the herein disclosed combinations of improvement agents have been found to improve the ignition characteristics of fuel oils. However, it may be that the combinations of improvement agents disclosed herein function at least in part by reducing the particle size of the fuel droplets in the combustion zone and by improving the fuel spray pattern in the combustion zone. In any event, regardless of the mechanism by which the combinations of improvement agents disclosed herein may function, aavilable experimental evidence demonstrates that the mixtures of amines and dialkylsulfosuccinates disclosed herein act in combination to produce a marked reduction in smoke- and soot-forming tendencies that is greater than might be expected from the effect of the individual materials themselves.

As indicated above the preferred dialkylsulfosuccinate for the purposes of this invention is sodium di(2-ethylhexyl)sulfosuccinate. However, the invention is not limited to the use of this material and other equivalent dialkylsulfosuccinates can be used. The dialkylsulfosuccinates that are useful for the purposes of this invention are those having a Draves wetting power value of about 0.15 to 0.5, and preferably 0.15 to 0.25. This class of salts can be represented by the following formula:



where C, H, O and S are, respectively, carbon, hydrogen, oxygen and sulfur; where R is an alkyl group containing 7 to 9 carbon atoms, at least 6 of which are in a straight chain, there being no group attached to the alpha carbon atom of said alkyl groups containing more than 7 carbon atoms; where Z is a salt-forming group selected from the class consisting of alkali metal, alkaline earth metal, ammonium and ethylolammonium, and where *n* is an integer equal to the valence of Z. In the foregoing general formula, R can represent identical or different alkyl groups of the type specified above.

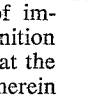
Especially effective results are obtained by the use of alkali metal dialkylsulfosuccinates wherein the alkyl groups are branched and contain 8 carbon atoms. An example of a dialkylsulfosuccinate with which excellent results have been obtained is the sodium salt of di(2-ethylhexyl)sulfosuccinate, the formula of which is:



where Na is sodium and C, H, O, and S are as indicated above.

Examples of other dialkylsulfosuccinates, the use of which is included by this invention, are the sodium, potassium, calcium, barium, ammonium, and triethylolammonium salts of di(n-heptyl), di(n-octyl), di(1-methylhexyl), di(1-butylamyl), di(1-isobutyl-3-methylbutyl), di(2-ethylhexyl), di(1-methylheptyl), and di(1-methyl-4-ethylhexyl) sulfosuccinates. Examples of salts of mixed esters that are suitable for the purposes of this invention are the sodium, potassium, calcium, barium, ammonium and triethylolammonium salts of mono-2-ethylhexyl-mono-1-methyl-4-ethylhexylsulfosuccinate, and mono-2-ethylhexyl-mono-1-methylheptylsulfosuccinate.

In general, any preferentially oil-soluble secondary or tertiary amine of the class indicated above can be used for the purposes of this invention. The amine employed should be preferentially oil-soluble to avoid excessive leaching of the amine from the oil by water with which the oil is contacted during shipment and storage. In general, the class of amines whose use is included by this invention can be represented by the general formula:



where R_1 is an open-chain or cyclic, saturated or unsaturated aliphatic hydrocarbon radical or an aromatic hydrocarbon radical, including both alkaryl and aralkyl groups, containing 6 to 22 carbon atoms, and preferably 8 to 18 carbon atoms, examples of which are n-hexyl, 2-ethylhexyl, Oxo-octyl, n-dodecyl, n-octadecenyl, n-octadecadienyl, phenyl, tolyl, benzyl, and naphthyl, where R_2 is an aliphatic hydrocarbon radical containing 1 to 22 carbon atoms that is either unsubstituted or substituted with nonhydrocarbon substituents such as amino, hydroxyl, or halogen, examples of such groups being methyl, ethyl, isopropyl, hydroxyethyl, aminoethyl, aminopropyl, and chlorobutyl, and radicals of the same kind as R_1, and where R_3 is hydrogen or a radical of the same class as R_1 or R_2. As will be apparent, the nature of the R_2 and R_3 N-substituents is less critical than that of the R_1 N-substituent. The important consideration insofar as the R_2 and R_3 substituents are concerned is that one or both must be a group other than hydrogen so as to create the necessary secondary or tertiary amino functional group whose presence is essential for the purposes of this invention.

The amines and dialkylsulfosuccinates disclosed herein can be employed in fuel oils in any proportion that will reduce the smoke and soot-forming tendencies of the oils. Naturally, the individual amines and dialkylsulfosuccinates of the classes disclosed herein are not exact equivalents, nor are all the individual fuel oils disclosed herein equally responsive to the addition agents disclosed herein. Accordingly, the optimum amounts of each components of the mixed addition agents disclosed herein may vary according to the nature of the amine, the dialkylsulfosuccinate and the fuel oil. Normally, some improvement in the combustion characteristics of a fuel oil of the kind disclosed herein will be obtained by the use of as little as 0.0025 percent of the dialkylsulfosuccinate, and the improvement thus obtained can be promoted by the concurrent use of as little as 0.0025 percent by weight of amine. Best results from the standpoint of combustion improvement are usually obtained with proportions of about 0.005 to about 0.05 percent each of the amine and the dialkylsulfosuccinate. Up to 2 percent of the combination of amine and dialkylsulfosuccinate can be used if desired, provided that each component is present in the proportion of at least 0.0025 percent by weight of the oil. Even greater amounts can be used, but no additional advantages are obtained from the standpoint of combustion improvement by such use.

The amines and dialkylsulfosuccinates disclosed herein can be added to the fuel oils whose combustion characteristics are to be improved either singly or in combination, and either as such, or in the form of concentrated solutions in solvents such as kerosene, toluene, or butyl alcohol. If desired, the combination of improvement agents may also have included therewith other addition agents designed to improve one or more properties of the fuel oil. Some stirring is desirable when mixing the amine and dialkylsulfosuccinate with the oil to facilitate rapid formation of a homogeneous mixture. However, stirring is not essential.

As indicated the amine-dialkylsulfosuccinate mixtures

disclosed herein are useful in conjunction with any fuel oil that normally tends to form substantial amounts of smoke and soot during combustion. Such oils are normally of the middle distillate or heavier fuel oil grades such as the so-called No. 2, No. 4, No. 5, and No. 6 fuel oils and the use of such oils is included by the present invention. Fuel oils of these grades are defined in the ASTM Standards on Petroleum Products and Lubricants under the ASTM specification D–396. The invention is especially important in connection with fuel oils having an API gravity of less than 34°, particularly when these oils contain an excess of about 20 percent aromatic hydrocarbons, as such oils involve serious smoke and soot-forming problems.

In order to demonstrate the effectiveness of the combustion improving mixtures disclosed herein, representative amine-dialkylsulfosuccinate mixtures were incorporated in separate samples of a No. 2 fuel oil in proportions of 0.03 percent by weight. Each of these fuel samples and a sample of uninhibited fuel oil were then subjected to a one-day smoke test. In order to demonstrate the combined effect of the amines and dialkylsulfosuccinates disclosed herein, tests were also carried out on samples of the fuel oil that contain only the amines and only the dialkylsulfosuccinate alone.

The one-day smoke test was carried out in a domestic oil burner (Timken Model OBC–110). Conventional burner controls were associated with the test apparatus in conjunction with electrical timer relays to provide a 20-minute "on," 10-minute "off" cycle of burner operation. After permitting a warm-up of at least one 20-minute "on" cycle of burner operation with maximum combustion air, smoke spot and CO_2 readings were taken at the middle of each "on" cycle for several cycles using different air gate settings to regulate the quantity of combustion air. Changes of gate setting were made during burner "off" phases of the cycle. Smoke spot readings were obtained by withdrawing flue gas from a sampling probe installed in the chimney pipe through a disc of No. 4 Whatman filter paper one inch in diameter for two minutes. A vacuum pump was used to maintain a pressure differential of 2¼ inches Hg across the disc. The smoke spot reading was determined by means of a photocell meter which had been calibrated by using a Bacharach-Shell smoke spot chart graduated in increasing shades of black ranging from 0 (clean disc) to 9 (black disc) as the standard. CO_2 readings were obtained by withdrawing flue gas through a sampling probe installed in a chimney pipe (in accordance with U.S. Department of Commerce Bulletin CA104–46) and by analyzing the flue gas for percent CO_2 in an Orsat-type flue gas analyzer.

The fuel employed in this test, hereinafter referred to as test fuel A, was an uninhibited commercial-type No. 2 fuel oil having an API gravity of 29.6° and an aromatics content of 44.1 weight percent (calculated), and consisting of 17.5 percent by volume hydrogenated West Texas straight-run No. 2 fuel oil distillate and 82.5 percent by volume fluid catalytically cracked gas oil boiling in the No. 2 fuel range, and having the following inspections:

Viscosity, SUV, Sec., at 100° F	34.1
Flash, P–M, ° F	180
Pour point, ° F	−10
Color, ASTM union	2
Sulfur, L., percent	0.54
Carbon residue, Conradson, percent on 10% bottoms	0.32
Distillation, gas oil ASTM D 158–54:	
Over point, ° F	382
End point, °F	608
10% distilled at, ° F	436
50% distilled at, ° F	496
90% distilled at, ° F	562
Recovery, percent	99.0
Residue, percent	1.0

The results of the foregoing tests are presented in the following table, wherein in Examples I and II, the amine-dialkylsulfosuccinate mixtures employed are specific embodiments of the mixed addition agents, apart from the compounded fuel oil, that are useful for the purposes of the present invention.

Table A

Test Fuel	Blank	Blank + Sodium Di(2-Ethyl-Hexyl)-Sulfo-Succinate	Blank + N,N-Di-n-Propyl-Aniline	Blank + 3-Dodecyl-Amino Propyl-amine	Example I	Example II
Sample Make-Up:						
Hydrogenated WTSR No. 2 Fuel Oil Distillate, percent Vol	17.5	17.5	17.5	17.5	17.5	17.5
FCC Light Catalytic Gas Oil, percent vol	82.5	82.5	82.5	82.5	82.5	82.5
Improvement Agent, percent wt. added, 50% Solution of—						
Sodium Di(2-Ethylhexyl)Sulfosuccinate in n-Butyl Alcohol		0.02			0.02	0.02
N,N-Di-n-Propylaniline			0.02		0.02	
3-Dodecylaminopropylamine				0.02		0.02
Inspection:						
Smoke v. CO_2 Performance Test, Timken Model OBC–110, Oilboiler II, Average Rate of Oil Flow 6.84 lb./hr.—						
Avg. Smoke Spot No. in the 10–13% CO_2 Burning Range	2.76	2.15	3.10	2.65	1.86	1.75
Avg. Reduction in Smoke Spot No. in the 10–13% CO_2 Burning Range		22.1	*+12.3	4.0	32.6	36.6

*Increase in Smoke Spot Number.

Comparison of the results obtained in connection with the Example I and Example II test fuel compositions, which contained amine-dialkylsulfosuccinate mixtures of the class disclosed herein, with the results obtained for the uninhibited fuel test sample and for the fuel test samples containing only amine or only dialkylsulfosuccinate clearly shows that the additive mixtures of the class disclosed herein produce much better results than might be expected from the results obtained with each improvement agent individually.

In order further to demonstrate the improvement in combustion characteristics obtainable by the addition agent mixtures disclosed herein, another sample of a No. 2 fuel oil that normally tended to form substantial amounts of smoke and soot during combustion and containing still another amine-dialkylsulfosuccinate mixture was subjected to a 10-day deposits combustion test. In accord-

ance with this test procedure the same furnace described in the preceding test was operated similarly as described except that the test was run for seven hours of cyclic operation each day for 10 days. Upon completion of the test, the soot deposits were collected from the heating surfaces of the furnace and weighed. In order to form a basis for comparison a test was also run on a sample of the oil containing only the amine.

The base fuel employed in the 10-day deposits test was a commercial-type No. 2 fuel oil having an API gravity of 29.5° and consisting of 35 percent by volume West Texas straight-run No. 2 fuel oil distillate and 65 percent by volume fluid catalytically cracked No. 2 fuel oil distillates having an aromatics content of 44.1 weight percent (calculated), and having a distillation range of about 354° to 621° F. and a 90 percent ASTM distillation point of 572° F., and having a carbon residue on 10 percent bottoms of 0.50 percent. The base fuel also contained 0.003 percent by weight of a commercial alkylamine phosphate corrosion inhibitor, which had no significant effect on the combustion characteristics of the oils.

The amine employed in the 10-day deposits test was a commercial mixture of secondary and tertiary amines marketed under the name "Santolene J." A sample of the amine mixture employed in the test was fractionally distilled to form a fraction having a boiling range of 221 to 225° C. and an average nitrogen content of 7.15 weight percent, a fraction having a boiling range of 230° to 232° C. and an average nitrogen content of 7.09 weight percent, a fraction having a boiling range of 241 to 248° C. and an average nitrogen content of 6.0 weight percent, and a fraction having a boiling range of 274° to 276° C. and an average nitrogen content of 4.20 weight percent. Each fraction gave positive tests for secondary and tertiary amines. Each of the above fractions was identified as a mixture of amines, as no solid derivatives were obtainable. On the basis of boiling points, the amine mixture appears to comprise mainly secondary and tertiary aromatic amines. The residue from the distillation contained surfur and nitrogen. An original sample of the mixed amines was found to contain 6.01 percent by weight nitrogen and 0.29 percent by weight sulfur.

The results of the 10-day deposits test were as follows:

Table B

Test Fuel	Base Fuel + Mixed Amines	Example III
Make-Up: Percent by wt.:		
35/65 WTSR/FCC Blend	100	100
Mixed Secondary and Tertiary Amines (added)	0.022	0.022
50 Percent Solution of Sodium Di(2-Ethylhexyl) Sufosuccinate in n-Butyl Alcohol (added)	----------	0.02
Inspection:		
10-Day Combustion Test in Timken, Model OBC-110 Burner at 11% CO_2—Flame Rim Deposits, wt. G	6.0	3.3
Ignition Time, sec. (avg.)	7.8	5.1

From the foregoing results it will be seen that the amine-dialkylsulfosuccinate mixtures of the kind disclosed herein are capable of effecting a substantial reduction in combustion deposits within the burner and that they are also capable of effecting an improvement in the ignition characteristics of the oil.

It will be understood that the specific embodiments set forth hereinabove are illustrative only and that the invention is not limited to the use of such specific combinations and that other amines and dialkylsulfosuccinates disclosed herein can be employed. For example, good results are obtainable by the substitution in the foregoing compounded fuel compositions in the same or equivalent amounts of the sodium, potassium, calcium, barium, ammonium, and triethylolammonium salts of di(n-heptyl), di(n-octyl), di(1-methylhexyl), di(1-butylamyl), di(1 - isobutyl-3-methylbutyl), di(2 - ethylhexyl), di(1 - methylheptyl), and di(1-methyl-4-ethylhexyl) esters of sulfosuccinic acid and by the substitution of the same or equivalent amounts of di-n-hexylamine, di-2-ethylhexylamine, di(Oxo-octyl)amine, dicocoamine (Armeen 2C), dicyclohexylamine, N-methyl-aniline, tri(Oxo-octyl)-amine, N,N-diisopropylbenzylamine, diphenylamine, N-isopropyl-p-methylaniline, N,N-dimethyl-p-methylaniline, N-propylaniline, N,N-diethyl-m-toluidine, N,N-dibutylbenzylamine, N-propyl-o-methylaniline, N-isobutylaniline, and N,N-diisobutylaniline.

Specific examples of other amine-dialkylsulfosuccinate mixtures that are useful for the purposes of this invention and examples of other compounded fuel oils containing the same are indicated in the following table:

Table C

Example	Combination Improvement Agent, 50% Solution of 1:1 Wt. Ratio Mixture in n-Butyl Alcohol		Wt. Percent Improvement Agent	Base Fuel
	Amine	Dialkylsulfosuccinate		
IV	3-Oleylaminopropylamine	Calcium Dioctylsulfosuccinate	0.04	Example I Fuel Oil.
V	3-Oleylaminopropylamine	Sodium Dioctylsulfosuccinate	0.04	Do.
VI	N-Isopropyl-p-Methylaniline.	Triethylolammonium Dioctylsulfosuccinate	0.04	Do.
VII	N-Propylaniline	Potassium Diheptylsulfosuccinate	0.04	Do.
VIII	N-Butylbenzylamine	Ammonium Di(1-Methylhexyl)-sulfosuccinate	0.04	Do.
IX	N,N-Diisobutylaniline	Barium Di(1-Butylamyl)-sulfosuccinate	0.04	Do.
X	Di-Oxo-Octylamine	Sodium Di(1-Isobutyl-3-Methylbutyl)sulfosuccinate.	0.08	10.2° API Gravity, No. 6 Fuel Oil.

If desired the fuel oil compositions of this invention may contain in addition to the compounds previously discussed oxidation inhibitors, corrosion inhibitors, antifoam agents, other ignition quality improvement agents, sludge inhibitors, color stabilizers, and/or other addition agents adapted to improve the oils in one or more respects.

Obviously, other modifications and variations of the invention as herein described may be resorted to without departing from the spirit or scope thereof. Therefore, only such limitations will be imposed as are indicated in the appended claims.

We claim:

1. A fuel oil composition comprising a major amount of a hydrocarbon fuel oil that normally tends to form smoke and soot during combustion, and containing an amount sufficient to reduce the smoke and soot-forming tendencies of the oil in the range of about 0.005 to about 2.0 percent by weight of a combination of (*a*) a preferentially oil-soluble member of the group consisting of secondary and tertiary amines at least one of whose N-substituents is selected from the group consisting of hydrocarbon radicals containing 6 to 22 carbon atoms, another of whose N-substituents is an aliphatic hydrocarbon radical containing 1 to 22 carbon atoms and whose remaining N-substituent is selected from the group consisting of hydrogen and a radical of the same class as the two previously described N-substituents, and (*b*) a member se-

lected from the group consisting of alkali metal, alkaline earth metal, ammonium, and ethylolammonium salts of a dialkyl-sulfosuccinate whose alkyl groups each contain 7 to 9 carbon atoms, at least six of which are in a straight chain, but there being no group containing more than 7 carbon atoms attached to the alpha-carbon atom of said alkyl groups, each of said amine and said salt of said dialkylsulfosuccinate being present in an amount of at least 0.0025 percent by weight of the oil.

2. The composition of claim 1 where said fuel oil is a distillate fuel oil.

3. The fuel oil composition of claim 1 where said hydrocarbon fuel oil has an API gravity less than about 34°.

4. The composition of claim 1 where the amount of said combination is about 0.01 to 0.1 percent by weight and each of said amine and said salt of said dialkylsulfosuccinate is present in an amount of at least about 0.005 percent by weight of the oil.

5. The fuel oil composition of claim 1 where said amine is a secondary amine, one of whose N-substituents is an aliphatic hydrocarbon radical, another of whose N-substituents is an amino-substituted aliphatic hydrocarbon radical, and whose remaining N-substituent is hydrogen.

6. A fuel oil composition comprising a major amount of a hydrocarbon fuel oil that normally tends to form smoke and soot during combustion and containing an amount sufficient to reduce the smoke and soot-forming tendencies of the oil in the range of about 0.005 to 2.0 percent by weight of the oil of a combination of N,N-di-n-propylaniline and sodium dioctylsulfosuccinate, each of said N,N-di-n-propylaniline and said dioctylsulfosuccinate being present in the oil in an amount of at least about 0.0025 percent by weight of the oil.

7. A fuel oil composition comprising a major amount of a hydrocarbon fuel oil that normally tends to form smoke and soot during combustion, and containing an amount sufficient to reduce the smoke and soot-forming tendencies of the oil in the range of about 0.005 to 2.0 percent by weight of the oil of 3-dodecyl-aminopropylamine, and sodium dioctylsulfosuccinate, each of said 3-dodecylaminopropylamine and said dioctylsulfosuccinate being present in an amount of at least about 0.0025 percent by weight of the oil.

8. A composition adapted to improve the combustion characteristics of hydrocarbon fuel oils that normally tend to form smoke and soot during combustion, consisting essentially of a combination of (*a*) a preferentially oil-soluble member of the group consisting of secondary and tertiary amines at least one of whose N-substituents is selected from the group consisting of hydrocarbon radicals containing 6 to 22 carbon atoms, another of whose N-substituents is an aliphatic hydrocarbon radical containing 1 to 22 carbon atoms and whose remaining N-substituent is selected from the group consisting of hydrogen and a radical of the same class as the two previously described N-substituents, and (*b*) a member selected from the group consisting of alkali metal, alkaline earth metal, ammonium, and ethylolammonium salts of a dialkyl-sulfosuccinate whose alkyl groups each contain 7 to 9 carbon atoms, at least six of which are in a straight chain, but there being no group containing more than 7 carbon atoms attached to the alpha-carbon atom of said alkyl groups, each of said amine and said salt of said dialkylsulfosuccinate being present in the weight ratio of about 1:20 to 20:1.

9. The composition of claim 8 where said amine is a secondary amine, one of whose N-substituents is an aliphatic hydrocarbon radical, another of whose N-substituents is an amino-substituted aliphatic hydrocarbon radical, and whose remaining N-substituent is hydrogen.

10. A composition adapted to improve the combustion characteristics of hydrocarbon fuel oils that normally tend to form smoke and soot during combustion, comprising a combination of N,N-di-n-propylaniline and sodium dioctylsulfosuccinate, each of said N,N-di-n-propylaniline and said dioctylsulfosuccinate being present in the combination in a weight ratio of about 1:5 to 5:1.

11. A composition adapted to improve the combustion characteristics of hydrocarbon fuel oils that normally tend to form smoke and soot during combustion, comprising a combination of 3-dodecylaminopropylamine and sodium dioctylsulfosuccinate, each of said 3-dodecylaminopropylamine and said dioctylsulfosuccinate being present in the combination in a weight ratio of about 1:5 to 5:1.

References Cited in the file of this patent

UNITED STATES PATENTS

2,579,890	Wies et al.	Dec. 25, 1951
2,684,292	Caron et al.	July 20, 1954

OTHER REFERENCES

"Organic Nitrogen Compounds," by Carbide and Carbon Chemical Corp., New York, Mar. 27, 1950, page 4.