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(54) **Use of cold flow improvers in fuel oil compositions**

Verwendung von Kaltfließverbesserern in Brennstoffzusammensetzungen

Utilisation d'agents améliorant l'écoulement à froid dans des compositions de carburant

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- **DANPING WEI, H.A. SPIKES: "The Lubricity of Diesel Fuels" WEAR, vol. 111, 1986, pages 217-235,**

Remarks:

The file contains technical information submitted after the application was filed and not included in this specification

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## Description

[0001] This invention relates to fuel oils, and to the use of additives to improve the characteristics of fuel oils, more especially of diesel fuel and kerosene.

5 [0002] Environmental concerns have led to a need for fuels with reduced sulphur content, especially diesel fuel and kerosene. However, the refining processes that produce fuels with low sulphur contents also result in a product of lower viscosity and a lower content of other components in the fuel that contribute to its lubricity, for example, polycyclic aromatics and polar compounds. Furthermore, sulphur-containing compounds in general are regarded as providing anti-wear properties and a result of the reduction in their proportions, together with the reduction in proportions of other

10 components providing lubricity, has been an increase in reported failures of fuel pumps in diesel engines using low-sulphur fuels, the failure being caused by wear in, for example, cam plates, rollers, spindles and drive shafts. [0003] This problem may be expected to become worse in future because, in order to meet stricter requirements on exhaust emissions generally, high pressure fuel pumps, including in-line, rotary and unit injector systems, are being introduced, these being expected to have more stringent lubricity requirements than present equipment, at the same

15 time as lower sulphur levels in fuels become more widely required. [0004] At present, a typical sulphur content in a diesel fuel is about 0.25% by weight. In Europe maximum sulphur levels are being reduced to 0.20%, and are expected to be reduced to 0.05%; in Sweden grades of fuel with levels below 0.005% (Class 2) and 0.001 % (Class 1) are already being introduced. A fuel oil composition with a sulphur level below 0.20% by weight is referred to herein as a low-sulphur fuel.

20 [0005] US-A 2,487,189 discloses diesel fuel oils containing small amounts of additives to lessen the wear of engine parts.

[0006] The present invention is based on the observation that a cold flow improver enhances the lubricity of a low-sulphur fuel.

[0007] In a first aspect of the invention, there is provided the use of a cold flow improver as defined in claim 1 to enhance the lubricity of a fuel oil composition having a sulphur content of at most 0.05% by weight.

25 [0008] Advantageously, the composition resulting from the use of the first aspect has a lubricity such as to give a wear scar diameter, as measured by the HFRR test (as hereinafter defined) at 60°C of at most 500 µm, such as at most 450µm, preferably at most 380 µm, more preferably at most 350 µm.

[0009] Advantageously, the petroleum-based fuel oil is a middle distillate fuel oil.

30 [0010] As used herein, the term "cold flow improver" refers to any additive which will lower the vehicle operability temperature relative to untreated base fuel, as evidenced, for example by lowering the pour point, the cloud point, the wax appearance temperature, the cold filter plugging point (hereinafter CFPP) or the Low Temperature Flow Test (LTFT) temperature of a fuel, or will reduce the extent of wax settlement in a fuel, especially a middle distillate fuel.

35 [0011] As used herein, the term "middle distillate" refers to fuel oils obtainable in refining crude oil as the fraction from the lighter, kerosene or jet fuel, fraction to the heavy fuel oil fraction. The fuel oils may also comprise atmospheric or vacuum distillate, cracked gas oil or a blend, in any proportions, of straight run and thermally and/or catalytically cracked distillate. Examples include kerosene, jet fuel, diesel fuel, heating oil, visbroken gas oil, light cycle oil, vacuum gas oil, light fuel oil and fuel oil. Such middle distillate fuel oils usually boil over a temperature range, generally within the range of 100°C to 500°C, as measured according to ASTM D86, more especially between 150°C and 400°C.

40 [0012] It is within the scope of the invention to include as a component of the composition a vegetable-based fuel oil, or "biofuel", for example a rapeseed methyl ester or vegetable oil.

[0013] The HFRR, or High Frequency Reciprocating Rig, test is that described according to CEC F-06-T-94 and ISO TC22/SC7/WG6N180.

[0014] The CFPP test is defined in "Journal of the Institute of Petroleum", 52 (1966) pp 173 to 185.

45 [0015] The cold flow improvers usable in the present invention will now be described in further detail.

Polar nitrogen compounds.

50 [0016] Such compounds are oil-soluble polar nitrogen compounds as defined in claim 1, wherein the hydrocarbyl groups preferably represent aliphatic hydrocarbyl groups containing 12 to 24 carbon atoms. The oil soluble polar nitrogen compound is generally one capable of acting as a wax crystal growth inhibitor in fuels.

[0017] Preferably, the hydrocarbyl group is linear or slightly linear, i.e. it may have one short length (1-4 carbon atoms) hydrocarbyl branch. When the substituent is amino, it carries more than one said hydrocarbyl group, which may be the same or different.

55 [0018] The term "hydrocarbyl" refers to a group having a carbon atom directly attached to the rest of the molecule and having a hydrocarbon or predominantly hydrocarbon character. Examples include hydrocarbon groups, including aliphatic (e.g. alkyl or alkenyl), alicyclic (e.g. cycloalkyl or cycloalkenyl), aromatic, and alicyclic-substituted aromatic, and aromatic-substituted aliphatic and alicyclic groups. Aliphatic groups are advantageously saturated. These groups may contain

non-hydrocarbon substituents provided their presence does not alter the predominantly hydrocarbon character of the , group. Examples include keto, halo, hydroxy, nitro, cyano, alkoxy and acyl. If the hydrocarbonyl group is substituted, a single (mono) substituent is preferred.

**[0019]** Examples of substituted hydrocarbonyl groups include 2-hydroxyethyl, 3-hydroxypropyl, 4-hydroxybutyl, 2-keto-propyl, ethoxyethyl, and propoxypropyl. The groups may also or alternatively contain atoms other than carbon in a chain or ring otherwise composed of carbon atoms. Suitable hetero atoms include, for example, nitrogen, sulphur, and, preferably, oxygen.

**[0020]** More especially, each amino substituent is bonded to a moiety via an intermediate linking group such as -CO-, -CO<sub>2</sub>(-), -SO<sub>3</sub>(-) or hydrocarbonylene. Where the linking group is anionic, the substituent is part of a cationic group, as in an amine salt group.

**[0021]** The polar nitrogen compound carries more than one amino substituent, and the linking groups for each substituent may be the same or different.

**[0022]** Suitable amino substituents are long chain C<sub>12</sub>-C<sub>40</sub>, preferably C<sub>12</sub>-C<sub>24</sub>, alkyl secondary, tertiary or quaternary amino substituents.

**[0023]** Preferably, the amino substituent is a dialkylamino substituent, which, as indicated above, may be in the form of an amine salt thereof; tertiary and quaternary amines can form only amine salts. Said alkyl groups may be the same or different.

**[0024]** Examples of secondary amino substituents include dioctadecylamino and methylbehnylamino. Mixtures of amino substituents may be present such as those derived from naturally occurring amines. A preferred amino substituent is the secondary hydrogenated tallow amino substituent, the alkyl groups of which are derived from hydrogenated tallow fat and are typically composed of approximately 4% C<sub>14</sub>, 31% C<sub>16</sub> and 59% C<sub>18</sub> n-alkyl groups by weight.

**[0025]** Said moiety may be monomeric (cyclic or non-cyclic) or polymeric. When non-cyclic, it may be obtained from a cyclic precursor such as an anhydride or a spirobisactone.

**[0026]** The cyclic ring system may include homocyclic, heterocyclic, or fused polycyclic assemblies, or a system where two or more such cyclic assemblies are joined to one another and in which the cyclic assemblies may be the same or different. Where there are two or more such cyclic assemblies, the substituents may be on the same or different assemblies, preferably on the same assembly. Preferably, the or each cyclic assembly is aromatic, more preferably a benzene ring. Most preferably, the cyclic ring system is a single benzene ring when it is preferred that the substituents are in the ortho or meta positions, which benzene ring may be optionally further substituted.

**[0027]** The ring atoms in the cyclic assembly or assemblies are preferably carbon atoms but may for example include one or more ring N, S or O atom, in which case or cases the compound is a heterocyclic compound.

Examples of such polycyclic assemblies include

**[0028]**

(a) condensed benzene structures such as naphthalene, anthracene, phenanthrene, and pyrene;

(b) condensed ring structures where none of or not all of the rings are benzene such as azulene, indene, hydroindene, fluorene, and diphenylene oxides:

(c) rings joined "end-on" such as diphenyl;

(d) heterocyclic compounds such as quinoline, indole, 2:3 dihydroindole, benzofuran, coumarin, isocoumarin, benzothiofene, carbazole and thiodiphenylamine;

(e) non-aromatic or partially saturated ring systems such as decalin (i.e. decahydronaphthalene),  $\alpha$ -pinene, cardinene, and bornylene; and

(f) three-dimensional structures such as norbornene, bicycloheptane (i.e. norbornane), bicyclooctane, and bicyclooctene.

**[0029]** Examples of polar nitrogen compounds are described below:

(i) an amine salt and/or amide of a poly-carboxylic acid, e.g. having up to 4 carboxylic acid groups. It may be made, for example, by reacting at least one molar proportion of a hydrocarbonyl substituted amine with a molar proportion of the acid or its anhydride.

When an amide is formed, the linking group is -CO-, and when an amine salt is formed, the linking group is -CO<sub>2</sub>(-).

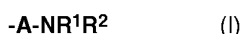
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The moiety may be cyclic or non-cyclic. Examples of cyclic moieties are those where the acid is cyclohexane 1,2-dicarboxylic acid; cyclohexane 1,2-dicarboxylic acid; cyclopentane 1,2-dicarboxylic acid; and naphthalene dicarboxylic acid. Generally, such acids have 5 to 13 carbon atoms in the cyclic moiety. Preferred such cyclic acids are benzene dicarboxylic acids such as phthalic acid, isophthalic acid, and terephthalic acid, and benzene tetracarboxylic acids such as pyromellitic acid, phthalic acid being particularly preferred. US-A-4,211,534 and EP-A-272,889 describes polar nitrogen compounds containing such moieties.

Examples of non-cyclic moieties are those when the acid is a long chain alkyl or alkylene substituted dicarboxylic acid such as a succinic acid, as described in US-A-4,147,520 for example.

Other examples of non-cyclic moieties are those where the acid is a nitrogen-containing acid such as ethylene diamine tetracetic acid and nitriloacetic acid, as described in DE-A-3,916,366 (equivalent to CA-A-2,017,126) (BASF). Further examples are the moieties obtained where a dialkyl spirobis lactone is reacted with an amine as described in EP-A-413,279 (Hoechst).

(ii) WO 9304948 describes a chemical compound comprising or including a cyclic ring system, the compound carrying at least two substituents of the general formula (I) below on the ring system



where A is an aliphatic hydrocarbyl group that is optionally interrupted by one or more hetero atoms and that is straight chain or branched, and R<sup>1</sup> and R<sup>2</sup> are the same or different and each is independently a hydrocarbyl group containing 9 to 40 carbon atoms optionally interrupted by one or more hetero atoms, the substituents being the same or different and the compound optionally being in the form of a salt thereof.

**[0030]** Preferably, A has from 1 to 20 carbon atoms and is preferably a methylene or polymethylene group.

**[0031]** Each hydrocarbyl group constituting R<sup>1</sup> and R<sup>2</sup> in the invention (Formula 1) may for example be an alkyl or alkylene group or a mono- or poly-alkoxyalkyl group. Preferably, each hydrocarbyl group is a straight chain alkyl group. The number of carbon atoms in each hydrocarbyl group is preferably 16 to 40, more preferably 16 to 24.

**[0032]** Also, it is preferred that the cyclic system is substituted with only two substituents of the general formula (I) and that A is a methylene group.

**[0033]** Examples of salts of the chemical compounds are the acetate and the hydrochloride.

**[0034]** The compounds may conveniently be made by reducing the corresponding amide which may be made by reacting a secondary amine with the appropriate acid chloride. WO 9407842 describes other compounds (Mannich bases) in this classification.

(v) A condensate of long chain secondary amine with a carboxylic acid-containing polymer.

**[0035]** Specific examples include polymers such as described in GB-A-2,121,807, FR-A-2,592,387 and DE-A-3,941,561; and also esters of telemer acid and alkanoloamines such as described in US-A-4,639,256; and the reaction product of an amine containing a branched carboxylic acid ester, an epoxide and a mono-carboxylic acid polyester such as described in US-A4,631,071.

**[0036]** EP-0,283,292 describes amide containing polymers and EP-0,343,981 describes amine-salt containing polymers.

**[0037]** It should be noted that the polar nitrogen compounds may contain other functionality such as ester functionality.

**[0038]** The flow improver is advantageously employed in a proportion within the range of from 0.001 to 1 %, e.g. from 0.01 % to 1 % advantageously 0.05% to 0.5%, and preferably from 0.075 to 0.25%, by weight, based on the weight of fuel.

### EXAMPLES

**[0039]** The following Examples illustrate the invention:

**[0040]** In the examples, the HFRR test was employed under the following conditions, wear being measured at 60°C throughout.

LOAD	2N
STROKE.	1 mm (0.5 mm AMPLITUDE)
FREQUENCY	50 Hz
TEMPERATURE	60°C
METALLURGY	BALL ANSI 52,100 (hardened bearing tool steel) 645 HV 30 FLAT ANSI 52 100 (bearing tool steel) 180 HV 30

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(continued)

DURATION 75 minutes

- 5 [0041] Wear was measured at the end of the test.  
[0042] Various additives were tested in Fuels I, II and III.  
[0043] Fuel I is a Class 1 diesel fuel commercially available in Sweden. The characteristics of the fuel were as follows:

10	Specific Gravity:	0.8088
	Sulphur:	0.001 wt%
	Distillation, °C, IBP	186
	10%	203
	50%	225
15	95%	273

- [0044] The HFRR results on the fuel alone were as follows:

20 WEAR,  $\mu\text{m}$ .  
701  
(results are mean of two tests)

- [0045] Fuel II has the following characteristics

25	Specific Gravity	0.8184
	Sulphur	0.03 wt%
	Distillation, °C, IBP	156
	10%	192
30	20%	202
	50%	233
	90%	303
	95%	326
	FBP	355

- 35 [0046] The HFRR results on the fuel alone were as follows:

40 WEAR,  $\mu\text{m}$   
575  
(result is the mean of two tests).

- [0047] Fuel III has the following characteristics:

45	Specific Gravity	0.8204
	Sulphur	0.03 wt%
	Distillation, °C, IBP	161
	10%	197
	20%	208
50	50%	239
	90%	301
	95%	314
	FBP	336

- 55 [0048] The HFRR result on the fuel alone was 585  $\mu\text{m}$  (mean of two tests)  
[0049] Various additives were used in the numbered Examples, the results and the treat rates, in ppm by weight of active ingredient based on the weight of the fuel, being given in the Tables.

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### Additives used

#### Example 1

5 [0050] A polar nitrogen compound, an N,N-dialkylammonium salt of 2-N'N' dialkylamidobenzoate, the product of reacting one mole of phthalic anhydride and two moles of di(hydrogenated tallow) amine.

#### Example 14

10 [0051] The reaction product of ethylene diamine tetracetic acid and di(hydrogenated tallow) amine in a mole ratio of 1:4.

#### Examples 15

15 [0052] The reaction product of nitroacetic acid and di(hydrogenated tallow) amine in a mole ratio of 1:3.

#### Example 16

20 [0053] The reaction product of one mole of an alkenyl spiro bislactone with one mole of di(hydrogenated tallow) amine and one mole of (hydrogenated tallow) amine.

#### RESULTS (FUEL I)

Example	Treat Rate, ppm	Wear, $\mu\text{m}$
1	1334	254
Fuel Alone	-	701

25 [0054] The results show that the flow improver enhances lubricity, as measured by wear reduction.

#### FUEL II

Example and (Treat Rate (ppm))	Wear $\mu\text{m}$
<u>(i)</u>	480
<u>(ii)</u>	480
<u>(iii)</u>	480

<u>(iv)</u>	1(60)	480
Fuel Alone		575

30 [0055] The results show that the flow improver enhances lubricity as measured by wear reductions.

#### FUEL III

Example and (Treat Rate (ppm))	Wear ( $\mu\text{m}$ )
14(300)	340
15(300)	380
16(300)	405
1(300)	385
Fuel Alone	585

35 [0056] The results show that the polar nitrogen compounds tested enhanced lubricity,

### **Claims**

55 1. The use of a cold flow improver, wherein the cold flow improver is an oil-soluble polar nitrogen compound carrying

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two or more substituents of the formula  $-NR^{13}R^{14}$ , where  $R^{13}$  and  $R^{14}$  each represent a hydrocarbyl group containing 8 to 40 carbon atoms provided that  $R^{13}$  and  $R^{14}$  may be the same or different, one or more of which substituents may be in the form of a cation derived therefrom, to enhance the lubricity of a fuel oil composition having a sulphur content of at most 0.05% by weight, wherein from 0.001 to 1 % by weight of the cold flow improver based on the weight of the fuel is present.

2. The use of claim 1 wherein the hydrocarbyl group represents an aliphatic hydrocarbyl group containing 12 to 24 carbon atoms.
3. The use of claim 2 wherein the hydrocarbyl group is a straight chain alkyl group.
4. The use of any of the preceding claims wherein the polar nitrogen compound is a wax crystal growth inhibitor.
5. The use of any of the preceding claims wherein the polar nitrogen compound is the reaction product of ethylene diamine tetraacetic acid and di(hydrogenated tallow) amine in a mole ratio of 1:4.
6. The use of any of claims 1 to 4, wherein the polar nitrogen compound is the reaction product of nitiloacetic acid and di(hydrogenated tallow) amine in a mole ratio of 1:3.
7. The use of any of claims 1 to 4, wherein the polar nitrogen compound is the N,N-dialkylammonium salt of 2-N',N'-dialkylamidobenzoate product of reacting one mole of phthalic anhydride and two moles of di(hydrogenated tallow) amine.
8. The use of any of the preceding claims wherein the fuel oil is a middle distillate fuel oil.
9. The use of any of the preceding claims wherein the enhancement in lubricity is such as to give a wear scar diameter to the fuel oil composition, as measured by the HFRR test at 60°C, of at most 500  $\mu\text{m}$ .

### Patentansprüche

1. Verwendung eines Kaltfließverbesserers, bei der der Kaltfließverbesserer eine öllösliche polare Stickstoffverbindung ist, die zwei oder mehr Substituenten mit der Formel  $-NR^{13}R^{14}$  trägt, wobei  $R^{13}$  und  $R^{14}$  jeweils für eine Kohlenwasserstoffgruppe stehen, die 8 bis 40 Kohlenstoffatome enthält, mit der Maßgabe, dass  $R^{13}$  und  $R^{14}$  gleich oder unterschiedlich sein können, wobei einer oder mehrere der Substituenten in Form eines davon abgeleiteten Kations vorliegen kann bzw. können, zur Verbesserung der Schmierfähigkeit einer Brennstoffölzusammensetzung mit einem Schwefelgehalt von höchstens 0,05 Gew.%, wobei bezogen auf das Gewicht des Brennstoffs 0,001 bis 1 Gew.% des Kaltfließverbesserers vorhanden ist.
2. Verwendung nach Anspruch 1, bei der die Kohlenwasserstoffgruppe für eine aliphatische Kohlenwasserstoffgruppe steht, die 12 bis 24 Kohlenstoffatome enthält.
3. Verwendung nach Anspruch 2, bei der die Kohlenwasserstoffgruppe eine geradkettige Alkylgruppe ist.
4. Verwendung nach einem der vorhergehenden Ansprüche, bei der die polare Stickstoffverbindung ein Inhibitor für das Wachstum von Paraffinkristallen ist.
5. Verwendung nach einem der vorhergehenden Ansprüche, bei der die polare Stickstoffverbindung das Reaktionsprodukt von Ethylendiamintetraessigsäure und (di(hydriertem Talg)amin im Molverhältnis von 1:4 ist.
6. Verwendung nach einem der Ansprüche 1 bis 4, bei der die polare Stickstoffverbindung das Reaktionsprodukt von Nitriooessigsäure und (di(hydriertem Talg)amin im Molverhältnis von 1:3 ist.
7. Verwendung nach einem der Ansprüche 1 bis 4, bei der die polare Stickstoffverbindung das N,N-Dialkylammoniumsalz des 2-N',N'-Dialkylamidobenzoatprodukts der Umsetzung von einem Mol Phthalsäureanhydrid und zwei Molen di(hydriertem Talg)amin ist.
8. Verwendung nach einem der vorhergehenden Ansprüche, bei der das Brennstofföl ein Mitteldestillatbrennstofföl ist.

9. Verwendung nach einem der vorhergehenden Ansprüche, bei der die Verbesserung der Schmierfähigkeit derart ist, dass sie der Brennstoffölzusammensetzung einen durch den HFRR-Test bei 60°C gemessenen Verschleißnarbendurchmesser von höchstens 500 µm verleiht.

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## Revendications

1. Utilisation d'un agent améliorant l'écoulement à basse température, ledit agent améliorant l'écoulement à basse température étant un composé azoté polaire, soluble dans l'huile, portant deux ou plus de deux substituants de formule -NR<sup>13</sup>R<sup>14</sup>, dans laquelle R<sup>13</sup> et R<sup>14</sup> représentent chacun un groupe hydrocarbyle contenant 8 à 40 atomes de carbone, sous réserve que R<sup>13</sup> et R<sup>14</sup> puissent être identiques ou différents, un ou plusieurs de ces substituants pouvant être sous forme d'un cation qui en est dérivé, pour augmenter le pouvoir lubrifiant d'une composition de fuel-oil ayant une teneur en soufre d'au plus 0,05 % en poids, dans laquelle 0,001 à 1 % en poids de l'agent améliorant l'écoulement à basse température, sur la base du poids du carburant, est présent.
2. Utilisation suivant la revendication 1, dans laquelle le groupe hydrocarbyle représente un groupe hydrocarbyle aliphatique contenant 12 à 24 atomes de carbone.
3. Utilisation suivant la revendication 2, dans laquelle le groupe hydrocarbyle est un groupe alkyle à chaîne droite.
4. Utilisation suivant l'une quelconque des revendications précédentes, dans laquelle le composé azoté polaire est un inhibiteur de croissance des cristaux de paraffines.
5. Utilisation suivant l'une quelconque des revendications précédentes, dans laquelle le composé azoté polaire est le produit de réaction de l'acide éthylènediaminotétra-acétique et de la di(suif hydrogéné)amine en un rapport molaire de 1:4.
6. Utilisation suivant l'une quelconque des revendications 1 à 4, dans laquelle le composé azoté polaire est le produit de réaction de l'acide nitriloacétique et de la di(suif hydrogéné) amine en un rapport molaire de 1:3.
7. Utilisation suivant l'une quelconque des revendications 1 à 4, dans laquelle le composé azoté polaire est le sel de N,N-dialkylammonium d'un 2-N',N'-dialkylaminobenzoate consistant en le produit de réaction d'une mole d'anhydride phtalique et de deux moles de di(suif hydrogéné)amine.
8. Utilisation suivant l'une quelconque des revendications précédentes, dans laquelle le fuel-oil est un fuel-oil distillé moyen.
9. Utilisation suivant l'une quelconque des revendications précédentes, dans laquelle l'augmentation du pouvoir lubrifiant est telle qu'elle confère un diamètre de cicatrice d'usure à la composition de fuel-oil, de la manière mesurée par le test HFRR à 60°C, d'au plus 500 µm.

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### REFERENCES CITED IN THE DESCRIPTION

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