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# DESCRIPTION

Description

## TECHNICAL FIELD

**[0001]** The present invention pertains to a novel hydrogen sulphide and mercaptans scavenging composition comprising an oxazolidine compound and a specific additive. The present invention also pertains to the use of the additive to improve the efficiency of an oxazolidine compound for scavenging hydrogen sulphide and mercaptans in hydrocarbon streams. The present invention also relates to a method for scavenging hydrogen sulphide and/or mercaptans comprising contacting a hydrocarbon stream such as crude oil, fuel or natural gas with the scavenging composition of the invention.

## BACKGROUND OF THE INVENTION

**[0002]** Hydrogen sulphide is a colourless and fairly toxic, flammable and corrosive gas which also has a characteristic odour at a very low concentration. Hydrogen sulphide dissolves in hydrocarbon and water streams and is also found in the vapour phase above these streams and in natural gas. The hydrogen sulphide emissions can therefore be a nuisance to workers operating in the drilling, production, transport, storage, and processing of crude oil and in the storage of fuel. Hydrogen sulphide may also react with hydrocarbon components present in fuel. It would therefore be desirable for the workers' comfort and safety to reduce or even eliminate the hydrogen sulphide emissions during the manipulation of said products.

**[0003]** Legislation has been in place for years, imposing strict regulations on hydrogen sulphide levels of hydrocarbon streams pipelines, and in storage and shipping containers. A variety of chemical scavengers are available to reduce both the concentration and corresponding hazard of hydrogen sulphide in produced gas, crude oil and refined products. Some of the most common methods for treating hydrogen sulphide include triazine, glyoxal, as well as metal-based scavengers. Glyoxal has been used extensively as hydrogen sulphide scavenger but suffers from a major drawback since aqueous glyoxal solutions are highly corrosive and cannot be used for a gas tower application. Triazines have recently become a more common chemical scavenger used for treating hydrogen sulphide from hydrocarbon streams. However, many drawbacks are reported that are linked to the use of triazines.

**[0004]** Others hydrogen sulphide scavengers have been developed, and among them scavengers based on oxazolidine, like 3,3'-methylenebis(5-methyloxazolidine), known as MBO.

A method for scavenging hydrogen sulphide from sour hydrocarbon substrates has been described in WO 98/02501. MBO presents the advantage to be less toxic and to create no scales in the conditions where triazine does.

**[0005]** However, this technology requires an important contact time in order to be efficient in sulphur removal and thus involves injection of higher doses.

**[0006]** Formulations of MBO with promoters, also named boosters, have been developed to enhance the efficiency of MBO. For example, WO 2017/102693 describes a composition comprising MBO and one or more additive selected among urea, urea derivatives, amino acids, guanidine, guanidine derivatives or 1,2-diols, said composition being used in the removal of sulphur compounds from process streams.

**[0007]** It would be useful to provide a composition enhancing the $H_2S$ scavenging properties of MBO.

## SUMMARY OF THE INVENTION

**[0008]** The present invention is disclosed in and by the appended claims.

**[0009]** The present invention relates to a composition for scavenging hydrogen sulphide and mercaptans from hydrocarbon streams, said composition comprising an oxazolidine compound and an additive selected from partial polyol esters comprising x ester units, y hydroxylated units and z ether units, x, y and z being integers such that x varies from 1 to 10, y varies from 1 to 10, and z varies from 0 to 50.

**[0010]** The present invention also relates to composition for scavenging hydrogen sulphide and mercaptans from hydrocarbon streams, said composition comprising an oxazolidine compound and an additive selected from partial polyol esters comprising x ester units, y hydroxylated units and z ether units, x, y and z being integers such that x varies from 1 to 10, y varies from 1 to 10, and z varies from 0 to 6.

**[0011]** According to the invention, the oxazolidine compound is a bisoxazolidine compound.

**[0012]** According to the invention, the polyols are chosen from the group comprising erythritol, xylitol, D-arabitol, L-arabitol, ribitol, sorbitol, malitol, isomalitol, lactitol, sorbitan, volemitol, mannitol, pentaerythritol, 2-hydroxymethyl-1,3-propanediol, 1,1,1-tri(hydroxymethyl) ethane, trimethylolpropane and carbohydrates such as sucrose, fructose, maltose, glucose and saccharose, preferably sorbitan.

**[0013]** According to a particular embodiment, the additive is selected from partial sorbitan ester of an unsaturated fatty acid comprising from 10 to 24 carbon atoms, preferably from optionally alkoxylated sorbitan oleate.

**[0014]** According to the invention, the composition comprises from 19 to 99%wt of oxazolidine compound(s) and from 1 to 50%wt of said additive(s), based on the total weight of the composition.

**[0015]** According to a particular embodiment, the weight ratio of oxazolidine compound(s) to said additive(s) ranges from 1 to 50, preferably from 2 to 30, more preferably from 4 to 20.

**[0016]** According to a particular embodiment, the composition further comprises a solvent, preferably in an amount ranging from 1 to 80°/wt, based on the total weight of the composition.

**[0017]** According to a particular embodiment, the composition comprises:

- From 19 to 80%wt of oxazolidine compound(s),
- From 1 to 30%wt of said additive(s), and
- From 1 to 80%wt of solvent(s),

based on the total weight of the composition.

**[0018]** The present invention also relates to a use of the additive for improving the efficiency of an oxazolidine compound for scavenging hydrogen sulphide and/or mercaptans in hydrocarbon streams.

**[0019]** The present invention also relates to a hydrocarbon stream comprising hydrocarbons and a composition according to the invention.

**[0020]** According to a particular embodiment, the hydrocarbons are selected from crude oil, fuel oil, fuel, Light Petroleum Gas and natural gas.

**[0021]** The present invention also relates to a method for scavenging hydrogen sulphide and/or mercaptan in hydrocarbon streams, comprising contacting the hydrocarbon stream with the composition according to the invention.

**[0022]** According to a particular embodiment of the method, the weight ratio between hydrogen sulphide contained in the hydrocarbon stream before the step of contacting and the composition ranges from 1:2 to 1:0.05, preferably from 1:1 to 1:0.1, more preferably from 1:0.9 to 1:0.2, even more preferably from 1:0.7 to 1:0.3 and advantageously from 1:0.8 to 1:0.4.

**[0023]** The composition of the present invention enables to reduce the treat rate, i.e. reduce the amount of MBO necessary to scavenge a given amount of hydrogen sulphide from the sulphur containing stream.

## DETAILED DESCRIPTION OF THE INVENTION

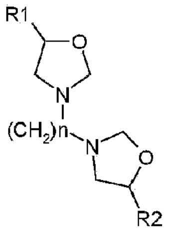
**[0024]** The present invention is disclosed in and by the appended claims.

**[0025]** The present invention concerns a hydrogen sulphide and mercaptans scavenging composition comprising at least one oxazolidine compound and at least one additive.

**[0026]** According to the present invention, the additive is selected from partial polyol ester(s), said polyol esters comprising x ester units, y hydroxylated units and z ether units, x, y and z being integers such that x varies from 1 to 10, y varies from 1 to 10, and z varies from 0 to 50.

**[0027]** According to an embodiment, the oxazolidine compound is selected from bisoxazolidines, i.e. compounds comprising two oxazolidine cycles.

**[0028]** According to the invention, the oxazolidine compound replies to formula (I):



(I)

wherein

n is an integer ranging from 1 to 6, preferably from 1 to 2;

R1 and R2, identical or different, are selected from a hydrogen atom and a linear, branched or cyclic alkyl or alkenyl groups having from 1 to 6 carbon atoms, preferably from 1 to 2 carbon atoms.

**[0029]** Preferably, the oxazolidine compound is 3,3'-methylenebis(5-methyloxazolidine).

**[0030]** According to the invention, the "additive" used in combination with the oxazolidine compound is also referred to by the expression the "synergistic additive".

**[0031]** The additive or synergistic additive of the invention is preferably selected from partial polyol ester(s), said polyol esters comprising x ester units, y hydroxylated units and z ether units, x, y and z being integers such that x varies from 1 to 4, y varies from 2 to 7, and z varies from 0 to 4.

**[0032]** According to an embodiment, the additive or synergistic additive of the invention is selected from partial polyol ester(s), said polyol esters comprising x ester units, y hydroxylated units and z ether units, x, y and z being integers such that x varies from 1 to 4, y varies from 2 to 7, and z varies from 0 to 50. Preferably, z varies from 1 to 30, more preferably from 2 to 20.

**[0033]** Within the meaning of the present invention, a partial polyol ester refers to a compound comprising at least one ester function and at least one hydroxyl function.

**[0034]** The synthesis of partial polyol esters is known per se; they can for example be prepared by esterification of fatty acid(s) and linear and/or branched polyols optionally comprising (hetero)cycles of 5 to 6 atoms bearing hydroxyl functions. The product(s) originating from this esterification reaction comprise(s) a distribution of ester units, hydroxylated units and ether units such that x varies from 1 to 4, y varies from 1 to 7 and z varies from 1 to 3. Generally this type of synthesis leads to a mixture of mono-, di-, tri- and optionally tetra-esters as well as small quantities of fatty acid(s) and polyols which have not reacted.

**[0035]** According to an embodiment, the polyol esters are obtained by esterification of fatty acid(s) and of linear and/or branched polyols optionally comprising heterocycles of 4 to 5 carbon atoms and an oxygen atom, bearing hydroxyl functions. Within the framework of the present invention, the polyols will be chosen from the linear polyols comprising more than three hydroxyl functions and the polyols comprising at least one (hetero)cycle of 5 or 6 atoms, preferably heterocycles of 4 to 5 carbon atoms and an oxygen atom, optionally substituted by hydroxyl groups, these polyols being able to be used alone or in a mixture. In the remainder of the present discussion, these polyols are referenced R in the formulations mentioned below.

**[0036]** Among the polyols R, the polyols with linear or branched hydrocarbon chains comprise at least four units represented in formula (II) below:

$$H\text{-}(OCH_2)_p\text{-}(CHOH)_q\text{-}(CH_2OH) \qquad (II)$$

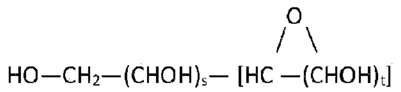
**[0037]** With p and q being integers, p being equal to or greater than 0, q is greater than 2, these numbers not being able to exceed 10.

**[0038]** Among the polyols R, the polyols with linear or branched hydrocarbon chains comprise at least four units represented in formula (II) below:

$$H\text{-}(OCH_2)_p\text{-}(CR3R4)_q\text{-}(CH_2OH) \qquad (III)$$

**[0039]** With p and q being integers, p being equal to or greater than 0, q is greater than 1, these numbers not being able to exceed 5, R3 and R4 are identical or different and represent either the hydrogen atom, or a $-CH_3$ or $-C_2H_5$ group or a $-CH_2\text{-}OH$ group.

**[0040]** Among the polyols R, some comprise at least one (hetero)cycle of 4 or 5 carbon atoms and an oxygen atom, optionally substituted by hydroxyl groups and correspond to general formula (IV) below:



$$\mathrm{HO{-}CH_2{-}(CHOH)_s{-}}\overset{\mathrm{O}}{\overbrace{[\mathrm{HC{-}(CHOH)_t}]}}$$

(IV)

with s and t being integers, and when s is equal to 1, t is equal to 3 and when s is zero, t is equal to 4.

**[0041]** Among the polyols R, some comprise at least two heterocycles of 4 or 5 carbon atoms and one oxygen atom connected by the formation of an acetal bond between a hydroxyl function of each ring, those heterocycles being optionally substituted by hydroxyl groups. According to the invention, the polyols are chosen from the group comprising erythritol, xylitol, D-arabitol, L-arabitol, ribitol, sorbitol, malitol, isomalitol, lactitol, sorbitan, volemitol, mannitol, pentaerythritol, 2-hydroxymethyl-1,3-propanediol, 1,1,1-tri(hydroxymethyl) ethane, trimethylolpropane and carbohydrates such as sucrose, fructose, maltose, glucose and saccharose, preferably sorbitan. According to a preferred variant, the partial polyol esters are chosen from the partial sorbitan esters, preferably sorbitan monooleate, used alone or in a mixture.

**[0042]** The fatty acids from which the esters according to the invention originate can be chosen from the fatty acids the chain length of which varies from 10 to 24 carbon atoms and/or at least one diacid substituted by at least one polymer, for example poly(iso)butene comprising from 8 to 100 carbon atoms. They are preferably chosen, in the case of the mono acids, from the stearic, isostearic, linolenic, oleic, linoleic, behenic, arachidonic, ricinoleic, palmitic, myristic, lauric and capric acids, and mixtures thereof and, in the case of the diacids from the alkyl- or alkenylsuccinic, alkyl- or alkenylmaleic acids. The fatty acids can originate from the transesterification or the saponification of vegetable oils and/or animal fats. The preferred vegetable oils and/or animal fats are chosen according to their oleic acid concentration. Reference may be made for example to Table 6.21 of Chapter 6 of the publication Carburants & Moteurs by J. C. Guibet and E. Faure, 2007 edition in which the compositions of several vegetable oils and animal fats are given. The fatty acids can also originate from tall oil fatty acids which comprise a majority of fatty acids, typically greater than or equal to 90% by mass as well as resin acids and unsaponifiables in a minority, i.e. in quantities generally less than 10%.

**[0043]** According to a particular embodiment, the synergistic additive is a partial sorbitan ester of an unsaturated fatty acid comprising from 10 to 24 carbon atoms or a sorbitan ester of an unsaturated fatty acid comprising from 10 to 24 carbon atoms comprising ether units, such as ethoxy groups, preferably a partial sorbitan oleate or an ethoxylated sorbitan oleate. Within the meaning of the present invention, the expression "sorbitan oleate" covers notably sorbitan monooleate, sorbitan dioleate and sorbitan trioleate.

**[0044]** According to the invention, the $H_2S$ and mercaptans scavenging composition comprises from 19 to 99%wt, preferably from 40 to 98%wt, more preferably from 55 to 79%, more preferably from 60 to 95%wt, even more preferably from 70 to 90%wt of oxazolidine compound(s) and from 0.5 to 50 %wt, preferably from 1 to 45%wt, even more preferably from

1.5 to 40°/wt, more preferably from 2 to 30%wt of synergistic additive(s), based on the total weight of the $H_2S$ and mercaptans scavenging composition. Preferably, the weight ratio of oxazolidine compound(s) to synergistic additive(s) ranges from 1 to 100, preferably from 1 to 50, more preferably from 2 to 30, even more preferably from 4 to 20.

**[0045]** According to an embodiment, the $H_2S$ and mercaptans scavenging composition further comprises at least one solvent.

**[0046]** Preferably, the solvent is selected from poly alkyl ethers, aliphatic or aromatic solvents, such as N-methylpyrrolidone, butyl carbitol, xylene, toluene, and benzene. It has been observed that the scavenging efficiency of the compositions of the invention is not dependent on the solvent. However, depending on the final use of the scavenging composition, a solvent having a dual solubility, i.e. a water solubility and a solubility in hydrocarbons, can be preferred. Butyl carbitol is a suitable solvent since it has this dual solubility.

**[0047]** According to this embodiment, the solvent represents from 1 to 80 % of the composition, preferably from 5 to 70°/wt, more preferably from 10 to 60%wt, even more preferably from 20 to 50%wt of the composition.

**[0048]** According to a particular embodiment of the invention, the composition comprises:

- From 10 to 98%wt, preferably from 30 to 80°/wt, more preferably from 40 to 60%wt of oxazolidine compound(s),
- From 0.5 to 30°/wt, preferably from 1 to 20°/wt, more preferably from 2 to 15%wt, even more preferably from 3 to 10%wt of the additive(s) defined in the invention, and
- From 1.5 to 80°/wt, preferably from 5 to 65%wt, more preferably from 15 to 55%wt of solvent(s),

based on the total weight of the composition.

**[0049]** According to a particular embodiment of the invention, the composition comprises:

- From 19 to 80°/wt, preferably from 30 to 70°/wt, more preferably from 40 to 60%wt of oxazolidine compound(s),
- From 1 to 30°/wt, preferably from 1.5 to 20°/wt, more preferably from 2 to 10%wt of the additive(s) defined in the invention, and
- From 1 to 80°/wt, preferably from 15 to 65%wt, more preferably from 25 to 55%wt of solvent(s),

based on the total weight of the composition.

**[0050]** According to an embodiment of the invention, the composition comprises:

- From 19 to 80°/wt, preferably from 30 to 70°/wt, more preferably from 40 to 60%wt of a bisoxazolidine,

- From 1 to 30°/wt, preferably from 1.5 to 20°/wt, more preferably from 2 to 10%wt of additive(s) selected from partial sorbitan ester of an unsaturated fatty acid comprising from 10 to 24 carbon atoms, and
- From 1 to 80°/wt, preferably from 15 to 65%wt, more preferably from 25 to 55%wt of solvent(s),

based on the total weight of the composition.

**[0051]** According to a particular embodiment of the invention, the composition comprises:

- From 10 to 98%wt, preferably from 30 to 80°/wt, more preferably from 40 to 60%wt of oxazolidine compound(s),
- From 0.5 to 30°/wt, preferably from 1 to 20°/wt, more preferably from 2 to 15%wt, even more preferably from 3 to 10%wt of the additive(s) selected from partial sorbitan ester of an unsaturated fatty acid comprising from 10 to 24 carbon atoms and sorbitan ester of an unsaturated fatty acid comprising from 10 to 24 carbon atoms comprising ether units, such as ethoxy groups, and
- From 1.5 to 80°/wt, preferably from 5 to 65%wt, more preferably from 15 to 55%wt of solvent(s),

based on the total weight of the composition.

**[0052]** According to an embodiment of the invention, the composition comprises:

- From 10 to 98%wt, preferably from 30 to 80°/wt, more preferably from 40 to 60%wt of bisoxazolidine compound(s),
- From 0.5 to 30°/wt, preferably from 1 to 20°/wt, more preferably from 2 to 15%wt, even more preferably from 3 to 10%wt of the additive(s) selected from sorbitan oleate and ethoxylated sorbitan oleate, and
- From 1.5 to 80°/wt, preferably from 55 to 65%wt, more preferably from 15 to 55%wt of solvent(s),

based on the total weight of the composition.

**[0053]** The present invention also concerns the use of the synergistic additive defined above for improving the efficiency of the oxazolidine compound defined above for scavenging hydrogen sulphide ($H_2S$) and/or mercaptans in hydrocarbon streams.

**[0054]** By hydrocarbon stream is meant either a single-phase hydrocarbon stream or a multiphase system comprising oil/water or oil/water/gas or gas/water.

**[0055]** Preferably, the weight ratio oxazolidine compound(s) to synergistic additive(s) ranges from 1 to 50, preferably from 2 to 30, preferably from 4 to 20.

**[0056]** Hydrocarbon streams contain $H_2S$ and/or mercaptans, in an amount for example ranging from 1 to 10 000 ppm. Mercaptans that can be removed from hydrocarbon streams within the framework of the present invention may be $C_1$-$C_6$ mercaptans, such as $C_1$-$C_4$ mercaptans.

**[0057]** The present invention also concerns the use of the composition defined above as a $H_2S$ and/or mercaptans scavenger in hydrocarbon streams, said hydrocarbon streams being preferably selected from crude oil, fuel and natural gas. The composition of the invention is contacted with hydrocarbon streams such as crude oil, fuel or natural gas in order to reduce the amount of hydrogen sulphide ($H_2S$) and mercaptans. Hydrocarbon streams may be selected from crude oils and fuels which typically comprise more than 60%wt of paraffins, preferably more than 70%wt of paraffins and even more preferably more than 75%wt of paraffins, based on the total weight of the crude oils and fuels. Hence, hydrocarbon streams may be selected from crude oils and fuels which typically comprise less than 30%wt of aromatics, preferably less than 10%wt of aromatics and even more preferably less than 5%wt of aromatics, based on the total weight of the crude oils and fuels.

**[0058]** Hydrocarbon streams contain $H_2S$ and/or mercaptans, in an amount for example ranging from 1 to 10 000 ppm. Mercaptans that can be removed from hydrocarbon streams within the framework of the present invention may be $C_1$-$C_6$ mercaptans, such as $C_1$-$C_4$ mercaptans.

**[0059]** According to an embodiment of the present invention, the weight ratio $H_2S$:scavenging composition ranges from 1:2 to 1:0.05, preferably from 1:1 to 1:0.1, more preferably from 1:0.9 to 1:0.2, even more preferably from 1:0.7 to 1:0.3 and advantageously from 1:0.8 to 1:0.4. In this ratio, $H_2S$ represents the amount of hydrogen sulphide in the hydrocarbon streams, before contacting with the scavenging composition of the invention.

**[0060]** The present invention also concerns hydrocarbon streams comprising hydrocarbons and the composition of the invention. The hydrocarbon streams considered in the present invention may be either single-phase hydrocarbon streams or multiphase systems comprising oil/water or oil/water/gas or gas/water.

**[0061]** Hydrocarbons may be selected from crude oil, fuel oil, fuel, Light Petroleum Gas and natural gas. Hydrocarbon streams may be selected from crude oils and fuels which typically comprise more than 60%wt of paraffins, preferably more than 70%wt of paraffins and even more preferably more than 75%wt of paraffins, based on the total weight of the crude oils and fuels. Hence, hydrocarbon streams may be selected from crude oils and fuels which typically comprise less than 30%wt of aromatics, preferably less than 10%wt of aromatics and even more preferably less than 5%wt of aromatics, based on the total weight of the crude oils and fuels.

**[0062]** Hydrocarbon streams contain $H_2S$ and/or mercaptans, in an amount for example ranging from 1 to 10 000 ppm. Mercaptans that can be removed from hydrocarbon streams within the framework of the present invention may be $C_1$-$C_6$ mercaptans, such as $C_1$-$C_4$ mercaptans.

**[0063]** The composition of the invention may represent from 0.0005 to 5 % by weight of the total weight of the hydrocarbon streams.

**[0064]** According to an embodiment of the present invention, the weight ratio $H_2S$:scavenging composition ranges from 1:2 to 1:0.05, preferably from 1:1 to 1:0.1, more preferably from 1:0.9 to 1:0.2, even more preferably from 1:0.7 to 1:0.3 and advantageously from 1:0.8 to 1:0.4. In this ratio, $H_2S$ represents the amount of hydrogen sulphide of the hydrocarbon streams, before contacting with the scavenging composition of the invention.

## EXAMPLES

**[0065]** The invention is now described with the help of following examples, which are not intended to limit scope of the present invention, but are incorporated to illustrate advantages of the present invention and best mode to perform it. The following examples also demonstrated effectiveness of scavenging compositions of the present invention, which can be a composition comprising of MBO (3,3'-methylenebis(5-methyloxazolidine) and sorbitan oleate or a composition comprising of MBO (3,3'-methylenebis(5-methyloxazolidine) and ethoxylated sorbitan trioleate.

### EXAMPLE 1: Protocol of measurement of $H_2S$ scavenging ability of the scavenging compositions of the invention under modified ASTM D-5705 conditions, as detailed below.

**[0066]** ASTM D-5705 is recommended for measurement of Hydrogen sulfide in a vapor phase above the residual fuel oils. Performance evaluation of the various products and formulations developed as Hydrogen Sulfide Scavengers were evaluated using modified ASTM D-5705 test method.

**[0067]** In typical experiment, 1 liter tin metal bottles with inner and outer caps were used to prepare and hold the test media. Dearomatized hydrocarbon solvents (with high boiling range i.e. >$120^0$C and flash point above 65°C with aromatic content less than 0.1%) is used for the tests.

**[0068]** In a representative experimental set, a defined amount of $H_2S$ saturated hydrocarbon solvent, typically between 2000 and 7000 ppm by weight of $H_2S$, was inserted in a well-sealed plastic drum containing 10 liters of dearomatized hydrocarbon solvent. The plastic drum was then kept on a reciprocating shaking machine for 5 min to allow proper mixing of the $H_2S$ gas.

500 mL of the $H_2S$ containing dearomatized hydrocarbon solvent were then transferred to first tin metal bottle and sealed with inner and outer caps. The tin metal bottle was then kept in a water bath at 60°C for two hours. After two hours, the tin metal bottle was taken out and cooled down to room temperature under running tap water and kept aside. An $H_2S$ detecting tube (Dräger tube, with typical detection limit ranging from 100 to 70 000 ppm by weight) was inserted in a rubber cork through a hole having the same diameter as the detecting tube. The sealed ends of the $H_2S$ detecting tube were opened with an appropriate opener, one end of the tube being attached to Dräger pump. The inner and outer caps of the tin metal bottles were opened and very quickly the rubber cork with $H_2S$ detector tube was inserted inside the opening of the tin metal bottle. The $H_2S$ gas in the vapor phase of the tin metal bottle was then pulled through the $H_2S$ measuring tube using Dräger pump attached at the other end of the tube. The detector tube was removed after complete decompression of the pump. $H_2S$ concentration was read from the tubes calibration scale (typically color change from colorless to brown). This reading was noted as a reference Blank reading of $H_2S$ amount.

**[0069]** Further, remaining $H_2S$ containing dearomatized hydrocarbon solvent was transferred into other tin metal bottles, each with 500 mL of the dearomatized hydrocarbon, all bottles being pre-charged with the $H_2S$ scavengers at different ratios of scavenger against $H_2S$, based on the Blank reading. Typical $H_2S$:scavenger ratios employed were 1:1, 1:0.8, 1:0.6, 1:0.4, 1:0.2 and 1:0.1. All the metal bottles were kept in a water bath for two hours at 60°C. Similar protocol was employed to measure the $H_2S$ in the vapor phase of all the bottles as used to make the Blank reading. The difference between the Blank $H_2S$ concentration and $H_2S$ concentration observed with different concentrations of the scavenging products and formulations are noted as % scavenging. A higher % Scavenging with lower concentration of the scavenging product is considered as better $H_2S$ scavenger for the set of experiment.

**[0070]** The protocol of measurement was repeated three times with each scavenging composition and the indicated percentage was calculated based on the average of the measurements.

**EXAMPLE 2: Measurement of $H_2S$ scavenging ability of the scavenging compositions of the invention under modified ASTM D-5705 conditions, as detailed in Example 1.**

**[0071]** Table 1 below summarizes the scavenging compositions that were tested. The synergistic additive used in Examples I1, I2 and I3 according to the invention was sorbitan oleate. This product is available from Oleon under the commercial name Radiasurf®. A sample of Radiasurf® 7348 was used in the following examples, at a dilution rate of about 50 wt% in xylene. The concentration of additive reported in Table 1 corresponds to the actual amount of active ingredient in the scavenging composition. As such, composition I1 comprises 10 wt% of additive solution at 45-55 wt% of active content, which correspond to 4.5-5.5 wt% of active ingredient in the scavenging composition.

**Table 1: scavenging compositions (in wt% based on the total weight of the composition)**

| $H_2S$ scavenging composition | MBO (wt%) | Synergistic additive (wt% of active ingredient) Radiasurf® 7348 | Solvent (wt%) xylene |
|---|---|---|---|
| C1 (comparative) | 50 | 0 | 50 |
| C2 (comparative) | 100 | 0 | 0 |
| I1 | 50 | 4.5-5.5 | 44.5-45.5 |
| I2 | 50 | 2.25-2.75 | 47.25-47.75 |
| I3 | 45 | 2.25-2.72 | 52.25-52.75 |

**[0072]** Table 2 below shows the percentage of $H_2S$ reduction based on the measured $H_2S$ amount in vapour phase after treatment with comparative MBO compositions (C1 and C2) and $H_2S$ scavenging compositions of the invention (I1, I2 and I3).

**Table 2: Scavenging efficiency (% of $H_2S$ reduction) of the scavenging compositions**

| $H_2S$ scavenging composition | Sample1 (blank) | Sample2 [1:0.1] | Sample3 [1:0.2] | Sample4 [1:0.4] | Sample5 [1:0.6] | Sample6 [1:0.8] | Sample7 [1:1] |
|---|---|---|---|---|---|---|---|
| **C1** (50% MBO) | 0 | 3 | 12 | 43 | 74 | 92 | **100** |
| **C2** (100% MBO) | 0 | 15 | 45 | 93 | **100** | **100** | **100** |
| **I1** (50% MBO; 4.5-5.5% additive) | 0 | 12 | 25 | 86 | 98 | **100** | **100** |
| **I2** (50% MBO; 2.25-2.75% additive) | 0 | 20 | 40 | 82 | 95 | **100** | **100** |
| **I3** (45% MBO; 2.25-2.75% addtive) | 0 | 10 | 30 | 76 | 98 | **100** | **100** |

**[0073]** The results in Table 2 clearly show that the scavenging compositions of the present invention are much more efficient than the scavenging compositions of the prior art.

**[0074]** If we refer for example to sample 4 wherein the weight ratio $H_2S$:scavenging composition is 1:0.4, we can observe that 86% of the $H_2S$ have been scavenged with the scavenging composition I1 according to the invention and even 82% of the $H_2S$ with the scavenging composition I2 comprising twice less additive than I1, whereas only 43% of the $H_2S$ have been scavenged with the scavenging composition C1 of prior art.

**EXAMPLE 3: Measurement of $H_2S$ scavenging ability of the synergistic additive under modified ASTM D-5705 conditions, as detailed in Example 1.**

**[0075]** The synergistic additive of the invention was also tested alone for its ability to scavenge hydrogen sulphide using the modified ASTM D-5705 method. The aim was to determine the contribution of the synergistic additive to the total scavenging ability of the composition.

**[0076]** The protocol of measurement was repeated three times with each composition of synergistic additive and the indicated percentage was calculated based on the average of the measurements.

**[0077]** Table 3 below shows the percentage of $H_2S$ reduction based on the measured $H_2S$ amount in vapour phase after treatment with the additive in a solvent. The tested comparative composition C3 comprises 5% by weight of sorbitan oleate and 95% by weight of xylene. Similarly C4 comprise 10% by weight of sorbitan oleate and 90% by weight of xylene.

**Table 3: % Scavenging efficiency (% of $H_2S$ reduction) of the synergistic additive**

| synergistic additive composition | Sample1 (blank) | Sample2 [1:0.1] | Sample3 [1:0.2] | Sample4 [1:0.4] | Sample5 [1:0.6] | Sample6 [1:0.8] | Sample7 [1:1] |
|---|---|---|---|---|---|---|---|
| **C3** (5% additive) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **C4** (10% additive) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**[0078]** The results in Table 3 clearly show that the synergistic additive has no direct effect on the scavenging of hydrogen sulphide. This confirms that said additive cannot itself scavenge $H_2S$ but has a boosting effect when used together with an $H_2S$ scavenging compound.

**EXAMPLE 4: Measurement of $H_2S$ scavenging ability of the scavenging compositions of the invention under modified ASTM D-5705 conditions**

**[0079]** The following protocol has been followed:

ASTM D-5705 is recommended for measurement of Hydrogen sulfide in a vapor phase above the residual fuel oils. Performance evaluation of the various products and formulations developed as Hydrogen Sulfide Scavengers were evaluated using modified ASTM D-5705 test method.

**[0080]** In a typical experiment, 1 liter tin metal bottles with silicon septa were used to prepare and hold in the two test media:

- Test media 1: a dearomatized hydrocarbon solvent having an initial boiling point higher than 120°C, a final boiling point lower than 250°C (the difference between the final boiling point and the initial boiling point ranges from 20 to 35°C) and a flash point above 65°C with aromatic content less than 0.1%wt and a paraffin content of more than 75°/wt,
- Test media 2: a dearomatized hydrocarbon solvent having an initial boiling point higher than 120°C, a final boiling point higher than 250°C (the difference between the final boiling point and the initial boiling point ranges from 40 to 50°C) and a flash point above 100°C with aromatic content less than 0.05%wt and a paraffin content of more than 75%wt.

**[0081]** In a representative experimental set, a defined amount of $H_2S$ saturated hydrocarbon solvent, typically between 2000 and 7000 ppm by weight of $H_2S$, was injected in 1 liter tin metal bottle pre-filled with 500 ml of dearomatized hydrocarbon solvent through the silicon septa fixed at the opening of the bottle using micro-syringe. The metal bottle was then kept on a reciprocating shaking machine for 5 min to allow proper mixing of the $H_2S$ gas. The tin metal bottle was then kept in a water bath at 60°C for two hours. After two hours, the tin metal bottle was taken out and cooled down to room temperature under running tap water and kept aside. An $H_2S$ detecting tube (Dräger tube, with typical detection limit ranging from 100 to 70 000 ppm by weight) was inserted in a rubber cork through a hole having the same diameter as the detecting tube. The sealed ends of the $H_2S$ detecting tube were opened with an appropriate opener, one end of the tube being attached to Dräger pump. The silicon septa mounted at the opening of the tin metal bottles was removed and very quickly the rubber cork with $H_2S$ detector tube was inserted inside the opening of the tin metal bottle. The $H_2S$ gas in the vapor phase of the tin metal bottle was then pulled through the $H_2S$ measuring tube using Dräger pump attached at the other end of the tube. The detector tube was removed after complete decompression of the pump. $H_2S$ concentration was read from the tubes calibration scale (typically color change from colorless to brown). This reading was noted as a reference Blank reading of $H_2S$ amount.

**[0082]** Further, same amount of $H_2S$ containing dearomatized hydrocarbon solvent was injected into other tin metal bottles, which are pre-filled with 500 mL of the dearomatized hydrocarbon, and $H_2S$ scavengers at different ratios of scavenger against $H_2S$, based on the Blank reading. Typical $H_2S$:scavenger ratios employed were 1:1, 1:0.8, 1:0.6, 1:0.4, 1:0.2 and 1:0.1. All the metal bottles were kept in a water bath for two hours at 60°C. Similar protocol was employed to measure the $H_2S$ in the vapor phase of all the bottles as used to make the Blank reading. The difference between the Blank $H_2S$ concentration and $H_2S$ concentration observed with different concentrations of the scavenging products and formulations are noted as % scavenging. A higher % Scavenging with lower concentration of the scavenging product is considered as better $H_2S$ scavenger for the set of experiment.

**[0083]** The protocol of measurement was repeated three times with each scavenging composition and the indicated percentage was calculated based on the average of the measurements.

**[0084]** Table 4 below summarizes the scavenging compositions that have been tested. The synergistic additive used in Examples I4, I5 and I6 is identical to the additive used in example 2, except that additive Radiasurf® has not been diluted and the solvent used is butyl carbirol (instead of xylene). The concentration of additive reported in Table 4 corresponds to the actual amount of active ingredient in the scavenging composition.

**Table 4: scavenging compositions (in wt% based on the total weight of the composition)**

| $H_2S$ scavenging composition | MBO (wt%) | Synergistic additive (wt% of active ingredient) Radiasurf® 7348 | Solvent (wt%) Butyl carbitol |
|---|---|---|---|
| C5 | 50 | 0 | 50 |
| I4 | 50 | 5 | 45 |
| I5 | 50 | 2.5 | 47.5 |
| I6 | 50 | 1 | 49 |

**[0085]** Table 5 below shows the percentage of $H_2S$ reduction based on the measured $H_2S$ amount in vapour phase after treatment with a comparative MBO composition (C5) and $H_2S$ scavenging compositions of the invention (I4, I5 and I6).

**Table 5** : **Scavenging efficiency** (% **of $H_2S$ reduction) of the scavenging compositions**

| $H_2S$ scavenging composition in Test media | Sample1 (blank) | Sample2 [1:0.1] | Sample3 [1:0.2] | Sample4 [1:0.4] | Sample5 [1:0.6] | Sample6 [1:0.8] | Sample7 [1:1] |
|---|---|---|---|---|---|---|---|
| **C5** in Test Media 1 | 0 | 5 | 12 | 43 | 74 | 92 | **100** |
| **C5** in Test Media 2 | 0 | 10 | 26 | 78 | 85 | **100** | **100** |
| **14** in Test Media 1 | 0 | 18 | 40 | 86 | 98 | **100** | **100** |
| **14** in Test Media 2 | 0 | 24 | 56 | 94 | **100** | **100** | **100** |

| $H_2S$ scavenging composition in Test media | Sample1 (blank) | Sample2 [1:0.1] | Sample3 [1:0.2] | Sample4 [1:0.4] | Sample5 [1:0.6] | Sample6 [1:0.8] | Sample7 [1:1] |
|---|---|---|---|---|---|---|---|
| **15** in Test Media 1 | 0 | 12 | 32 | 82 | 95 | **100** | **100** |
| **16** in Test Media 1 | 0 | 12 | 25 | 72 | 88 | **100** | **100** |

**[0086]** The results in Table 5 clearly show that the scavenging compositions of the present invention are much more efficient than the scavenging compositions of the prior art, in both hydrocarbon streams that have been used as test media.

**EXAMPLE 5: Measurement of $H_2S$ scavenging ability of the scavenging compositions of the invention under modified ASTM D-5705 conditions**

**[0087]** Similar experiments as example 4 have been performed, except that another synergistic additive has been used and the solvent used is xylene. The synergistic additive used is an ethoxylated trioleate sorbitan comprising 15°/mol of ethoxy groups, commercially available as a composition comprising 100% of active matter. Table 6 below summarizes the scavenging compositions that have been tested.

**Table 6: scavenging compositions (in wt% based on the total weight of the composition)**

| $H_2S$ scavenging composition | MBO (wt%) | Synergistic additive (wt% of active ingredient) | Solvent (wt%) xylene |
|---|---|---|---|
| C1 (comparative) | 50 | 0 | 50 |
| I7 | 50 | 5 | 45 |
| I8 | 50 | 2.5 | 47.5 |
| I9 | 50 | 1 | 49 |

**[0088]** Table 7 below shows the percentage of $H_2S$ reduction based on the measured $H_2S$ amount in vapour phase after treatment with comparative MBO composition (C1) and $H_2S$ scavenging compositions of the invention (I7, I8 and I9).

**Table 7 : Scavenging efficiency (% of $H_2S$ reduction) of the scavenging compositions**

| $H_2S$ scavenging composition in Test media | Sample1 (blank) | Sample2 [1:0.1] | Sample3 [1:0.2] | Sample4 [1:0.4] | Sample5 [1:0.6] | Sample6 [1:0.8] | Sample7 [1:1] |
|---|---|---|---|---|---|---|---|
| **C1** in Test Media 1 | 0 | 5 | 12 | 43 | 74 | 92 | **100** |
| **C1** in Test Media 2 | 0 | 10 | 26 | 78 | 85 | **100** | **100** |
| **17** in Test Media 1 | 0 | 18 | 36 | 80 | 96 | **100** | **100** |
| **17** in Test Media 2 | 0 | 18 | 50 | 90 | 95 | **100** | **100** |
| **18** in Test Media 1 | 0 | 12 | 28 | 74 | 92 | **100** | **100** |
| **19** in Test Media 1 | 0 | 10 | 24 | 67 | 90 | **100** | **100** |

**[0089]** The results in Table 7 clearly show that the scavenging compositions of the present invention are much more efficient than the scavenging compositions of the prior art, in both hydrocarbon streams that have been used as test media.

# REFERENCES CITED IN THE DESCRIPTION

Cited references

**Patent documents cited in the description**

- WO9802501A [0004]
- WO2017102693A [0006]

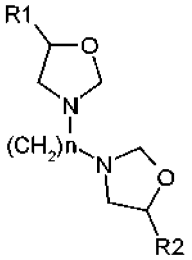
## Non-patent literature cited in the description

- **J. C. GUIBETE. FAURE**Carburants & Moteurs, 2007, [0042]

# SAMMENSÆTNINGER TIL FJERNELSE AF HYDROGENSULFID OG MERCAPTANER

## PATENTKRAV

1. Sammensætning til fjernelse af hydrogensulfid og mercaptaner fra carbonhydridstrømme, hvor nævnte sammensætning omfatter en oxazolidinforbindelse og et additiv udvalgt blandt partielle polyolestere, der omfatter x esterenheder, y hydroxylerede enheder og z etherenheder, hvor x, y og z er heltal, således at x varierer fra 1 til 10, y varierer fra 1 til 10, og z varierer fra 0 til 50, hvor sammensætningen omfatter fra 19 til 99 vægtprocent oxazolidinforbindelse(r) og fra 1 til 50 vægtprocent af nævnte additiv(er) baseret på fnævnte sammensætnings samlede vægt, hvor oxazolidinforbindelsen svarer til formel (I):



(I)

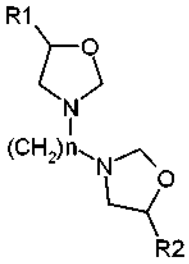
hvor

- n er et heltal, der spænder fra 1 til 6.

R1 og R2, som er identiske eller forskellige, udvælges blandt et hydrogenatom og en lineær, forgrenet eller cyklisk alkyl- eller alkenylgruppe med fra 1 til 6 carbonatomer, og

hvor polyolerne er valgt fra gruppen, der omfatter erythritol, xylitol, D-arabitol, L-arabitol, ribitol, sorbitol, malitol, isomalitol, lactitol, sorbitan, volemitol, mannitol, pentaerythritol, 2-hydroxymethyl-1,3-propandiol, 1,1,1-tri(hydroxymethyl) ethan, trimethylolpropan og kulhydrater såsom saccharose, fructose, maltose, glucose og saccharose.

2. Sammensætning ifølge krav 1, hvor oxazolidinforbindelsen svarer til formel (I):



(I)

hvor

- n er et heltal, der spænder fra 1 til 2.
- R1 og R2, som er identiske eller forskellige, vælges blandt et hydrogenatom og en lineær, forgrenet eller cyklisk alkyl- eller alkenylgruppe med fra 1 til 2 carbonatomer.

3. Sammensætning ifølge et hvilket som helst af kravene 1 til 2, hvor polyolerne er sorbitan.

4. Sammensætning ifølge et hvilket som helst af kravene 1 til 3, hvor additivet er valgt fra partiel sorbitanester af en umættet fedtsyre, der omfatter fra 10 til 24 carbonatomer, fortrinsvis fra sorbitanoleat eventuelt alkoxyleret.

5. Sammensætning ifølge et hvilket som helst af kravene 1 til 4, hvor vægtforholdet mellem oxazolidinforbindelse(r) og nævnte additiv(er) spænder fra 1 til 100, fortrinsvis fra 1 til 50, mere fortrinsvis fra 2 til 30, endnu mere fortrinsvis fra 4 til 20.

6. Sammensætning ifølge et hvilket som helst af kravene 1 til 5, der yderligere omfatter et opløsningsmiddel.

7. Sammensætning ifølge et hvilket som helst af kravene 1 til 6, karakteriseret ved at den omfatter:
   - fra 19 til 80 vægtprocent oxazolidinforbindelse(r)
   - fra 1 til 30 vægtprocent af nævnte additiv(er), og
   - fra 1 til 80 vægtprocent opløsningsmiddel(-ler)

   baseret på den samlede vægt af sammensætningen.

8. Anvendelse af det additiv, der er defineret i et hvilket som helst af kravene 1, 3, 4, til forbedring af effektiviteten af en oxazolidinforbindelse til fjernelse af hydrogensulfid og/eller mercaptaner i carbonhydridstrømme.

9. Carbonhydridstrøm, der omfatter carbonhydrider og en sammensætning ifølge et hvilket som helst af kravene 1 til 7.

10. Carbonhydridstrømme ifølge krav 9, hvor carbonhydriderne er valgt fra råolie, fyringsolie, brændstof, let petroleumsgas og naturgas.

11. Fremgangsmåde til fjernelse af hydrogensulfid og/eller mercaptan i carbonhydridstrømme, der omfatter at bringe carbonhydridstrømmen i kontakt med sammensætningen ifølge et hvilket som helst af kravene 1 til 7.

12. Fremgangsmåde ifølge krav 11, hvor vægtforholdet mellem hydrogensulfid indeholdt i carbonhydridstrømmen før kontakttrinnet og sammensætningen spænder fra 1:2 til 1:0,05, fortrinsvis fra 1:1 til 1:0,1, mere fortrinsvis fra 1:0,9 til 1:0,2, endnu mere fortrinsvis fra 1:0,7 til 1:0,3 og fordelagtigt fra 1:0,8 til 1:0,4.