

PROCESSES FOR REMOVING HYDROGEN SULFIDE FROM REFINED HYDROCARBON STREAMS

FIELD OF THE INVENTION

[0001] This invention relates generally to processing hydrocarbon media, and more particularly, to methods for removing hydrogen sulfide from a refined hydrocarbon stream.

BACKGROUND OF THE INVENTION

[0002] Hydrocarbon media, such as a refined hydrocarbon stream, may contain hydrogen sulfide, which is highly corrosive and poisonous in very small concentrations. The risk of exposure to hydrogen sulfide from handling hydrocarbon media is a health and safety concern during storage, transportation (shipping, truck or pipeline) and processing.

[0003] Hydrogen sulfide scavengers can be used to remove hydrogen sulfide from hydrocarbon media. One type of hydrogen sulfide scavenger is glyoxal. During production of glyoxal, acidic byproducts are often formed. These byproducts can lead to increased corrosion rates during hydrocarbon processing. When glyoxal is added to a refined hydrocarbon stream, the acidic byproducts, which are not soluble in the refined hydrocarbon stream, can settle out from the refined hydrocarbon stream into a separate aqueous phase. For example, the aqueous phase may run along the bottom of the processing or refinery equipment as small tributaries in pipelines or stagnate at the bottom of holding tanks. This acidic aqueous phase is highly corrosive and can cause troughing in the processing or refinery equipment.

[0004] What is needed is an improved method for removing hydrogen sulfide from a refined hydrocarbon stream without causing corrosion to processing equipment.

BRIEF DESCRIPTION OF THE INVENTION

[0005] In one embodiment, a method for reducing the amount of hydrogen sulfide present in a refined hydrocarbon stream and reducing the amount of corrosion in processing equipment contacting the refined hydrocarbon stream, said method includes adding a corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment to protect the processing equipment and adding glyoxal to the refined hydrocarbon stream in contact with the protected processing equipment, wherein said corrosion inhibitor includes an organic soluble compound having a nitrogen-containing ring.

[0006] The various embodiments provide an improved hydrogen scavenging process for refined hydrocarbon streams that reduces hydrogen sulfide while minimizing corrosion to processing equipment.

DETAILED DESCRIPTION OF THE INVENTION

[0007] The singular forms “a,” “an” and “the” include plural referents unless the context clearly dictates otherwise. The endpoints of all ranges reciting the same characteristic are independently combinable and inclusive of the recited endpoint. All references are incorporated herein by reference.

[0008] The modifier “about” used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., includes the tolerance ranges associated with measurement of the particular quantity).

[0009] “Optional” or “optionally” means that the subsequently described event or circumstance may or may not occur, or that the subsequently identified material may or may not be present, and that the description includes instances where the event or

circumstance occurs or where the material is present, and instances where the event or circumstance does not occur or the material is not present.

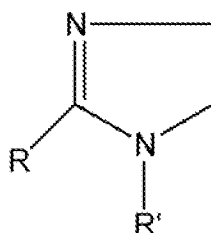
[0010] In one embodiment, a method for reducing the amount of hydrogen sulfide present in a refined hydrocarbon stream and reducing the amount of corrosion in processing equipment contacting the refined hydrocarbon stream, said method includes adding a corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment to protect the processing equipment and adding glyoxal to the refined hydrocarbon stream in contact with the protected processing equipment, wherein said corrosion inhibitor includes an organic soluble compound having a nitrogen-containing ring.

[0011] The refined hydrocarbon stream may be any type of refined hydrocarbon stream containing hydrogen sulfide. In one embodiment, the refined hydrocarbon stream includes, but is not limited to, gas oil, naphtha, FCC slurry, diesel fuel, fuel oil, jet fuel, gasoline, kerosene or vacuum residua. In one embodiment, the refined hydrocarbon stream may be at an elevated temperature. In another embodiment, the refined hydrocarbon stream may be at a temperature of from about ambient to about 150°C. In another embodiment, the refined hydrocarbon stream may be at a temperature of from about 40°C to about 100°C.

[0012] The processing equipment in contact with the refined hydrocarbon stream may be any type of equipment that can be used for processing the refined hydrocarbon stream, such as pipelines and holding tanks. Processing equipment subject to corrosion is generally processing equipment made of carbon steel, but any type of processing equipment may be protected.

[0013] The corrosion inhibitor includes an organic soluble compound having a nitrogen-containing ring. In one embodiment, the corrosion inhibitor is miscible in the refined hydrocarbon stream.

[0014] In one embodiment, the nitrogen-containing ring may be a five-membered ring or a six-membered ring. In one embodiment, the nitrogen-containing ring may be an imidazoline derivative. In another embodiment, the corrosion inhibitor may be a fatty acid imidazoline. In one embodiment, the fatty acid imidazoline has the following structure:



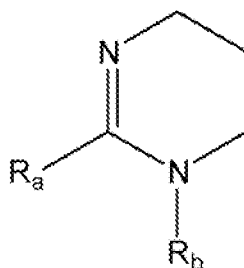
wherein R and R' are each, separately, a C₆ to C₃₆ alkyl, alkylene or aromatic group. In another embodiment, R and R' are each, separately, a C₈ to C₂₂ alkyl, alkylene or aromatic group. In another embodiment, R and R' are each, separately, a C₁₆ to C₁₈ alkyl, alkylene or aromatic group. In another embodiment, R and R' are each, separately, a C₆ to C₃₆ alkyl, alkylene or aromatic group having branched alkyl groups. In one embodiment, R may be stearyl, naphthyl, palmyl, oyl, linolyl or linolenyl. In one embodiment, R' may be stearyl, naphthyl, palmyl, oyl, linolyl or linolenyl.

[0015] In one embodiment, the fatty acid imidazoline compound includes, but is not limited to, stearic acid imidazoline, naphthenic acid imidazoline, palmitic acid imidazoline, oleic acid imidazoline, linoleic acid imidazoline or linolenic acid imidazoline.

[0016] In one embodiment, the fatty acid imidazoline may contain a mixture of two or more fatty acid imidazoline compounds.

[0017] In one embodiment, fatty acid imidazolines may be prepared by the condensation reaction of at least one fatty acid and diethylenetriamine. In one embodiment, the fatty acids may have a C₆ to C₃₆ chain length. In another embodiment, the fatty acids may have a C₈ to C₂₂ chain length. In another embodiment, the fatty acids may have a C₁₆ to C₁₈ chain length. In one embodiment, the fatty acids may include natural acids derived from tall oils, oleic acid, stearic acid, palmitic acid, linoleic acid, linolenic acid or naphthenic acid or may include synthetically prepared fatty acids. The synthetically prepared fatty acids may include acids with an even number of carbon atoms or an odd number of carbon atoms. In one embodiment, the condensation reaction may be at a reaction temperature of up to about 400°F. In another embodiment, the reaction temperature may be from about 200°F to about 400°F.

[0018] In another embodiment, the nitrogen-containing ring may be a pyrimidine derivative. In another embodiment, the corrosion inhibitor may be a fatty acid pyrimidine. In another embodiment, the fatty acid pyrimidine has the following structure:



wherein R_a and R_b are each, separately, a C₆ to C₃₆ alkyl, alkylene or aromatic group. In another embodiment, R_a and R_b are each, separately, a C₈ to C₂₂ alkyl, alkylene

or aromatic group. In another embodiment, R_a and R_b are each, separately, a C_{16} to C_{18} alkyl, alkylene or aromatic group. In one embodiment, R_a and R_b are each, separately, a C_6 to C_{36} alkyl, alkylene or aromatic group having branched alkyl groups. In one embodiment, R_a may be stearyl, naphthyl, palmyl, oyl, linolyl or linolenyl. In one embodiment, R_b may be stearyl, naphthyl, palmyl, oyl, linolyl or linolenyl.

[0019] In one embodiment, the fatty acid pyrimidine compound includes, but is not limited to, stearic acid pyrimidine, naphthenic acid pyrimidine, palmitic acid pyrimidine, oleic acid pyrimidine, linoleic acid pyrimidine or linolenic acid pyrimidine.

[0020] In one embodiment, the fatty acid pyrimidine may contain a mixture of two or more fatty acid pyrimidine compounds.

[0021] In one embodiment, fatty acid pyrimidines may be prepared by the condensation reaction of at least one fatty acid with a fatty acid-derived 1,3-propane diamine and paraformaldehyde. In one embodiment, the fatty acids may have a C_6 to C_{36} chain length. In another embodiment, the fatty acids may have a C_8 to C_{22} chain length. In another embodiment, the fatty acids may have a C_{16} to C_{18} chain length. In one embodiment, the fatty acids may include natural acids derived from tall oils, oleic acid, stearic acid, palmitic acid, linoleic acid, linolenic acid or naphthenic acid or may include synthetically prepared fatty acids. The synthetically prepared fatty acids may include acids with an even number of carbon atoms or an odd number of carbon atoms. In one embodiment, the condensation reaction may be at a reaction temperature of up to about 400°F. In another embodiment, the reaction temperature may be from about 200°F to about 400°F.

[0022] The corrosion inhibitor may be added to the refined hydrocarbon stream in contact with the processing equipment to protect the processing equipment. In one

embodiment, the corrosion inhibitor is added to the refined hydrocarbon stream, which then contacts the processing equipment. In another embodiment, the corrosion inhibitor is added to the refined hydrocarbon stream while it is in contact with the processing equipment.

[0023] The corrosion inhibitor is added to the refined hydrocarbon stream in any conventional manner. In one embodiment, the corrosion inhibitor may be injected into the refined hydrocarbon stream. In one embodiment, the corrosion inhibitor may be injected into the refined hydrocarbon stream by a conventional in-line injection system and may be injected at any point in-line suitable to allow the corrosion inhibitor to mix with the refined hydrocarbon stream. The corrosion inhibitor may be added to the refined hydrocarbon stream in a continuous manner or can be added in one or more batch modes and repeated additions may be made.

[0024] In another embodiment, the corrosion inhibitor is injected into the refined hydrocarbon stream as the refined hydrocarbon stream is flowing through a pipeline. In one embodiment, the corrosion inhibitor is injected into the refined hydrocarbon stream as it enters a pipeline. In another embodiment, the corrosion inhibitor is injected into refined hydrocarbon stream in a holding tank. In another embodiment, the corrosion inhibitor is injected into the refined hydrocarbon stream as it enters a holding tank.

[0025] The corrosion inhibitor disperses into the refined hydrocarbon stream and eventually contacts the processing equipment and deposit onto the processing equipment, forming a protective coating or film. The corrosion inhibitor may be added in any amount suitable for forming a protective coating or film on the processing equipment. In one embodiment, the corrosion inhibitor may be added to the refined hydrocarbon stream

in an amount of from about 2 ppm by volume to about 200 ppm by volume, based on the volume of the refined hydrocarbon stream. In another embodiment, the corrosion inhibitor may be added to the refined hydrocarbon stream in an amount of from about 5 ppm by volume to about 100 ppm by volume, based on the volume of the refined hydrocarbon stream. In another embodiment, the corrosion inhibitor is added to the refined hydrocarbon stream in an amount of from about 10 ppm by volume to about 100 ppm by volume, based on the volume of the refined hydrocarbon stream. In another embodiment, the corrosion inhibitor is added to the refined hydrocarbon stream in an amount of from about 20 ppm by volume to about 100 ppm by volume, based on the volume of the refined hydrocarbon stream. The corrosion inhibitor may be added in a single batch or may be added in continuing dosages to the refined hydrocarbon stream.

[0026] The corrosion inhibitor will begin to deposit evenly on the processing equipment as it contacts the equipment. A protective coating will form on the processing equipment as the refined hydrocarbon stream containing the corrosion inhibitor continues to contact the processing equipment. The amount of time suitable for forming a protective coating will depend on many factors, such as the amount of corrosion inhibitor in the refined hydrocarbon stream, the temperature of the refined hydrocarbon stream, the amount of time that the refined hydrocarbon stream is in contact with the processing equipment and the speed at which the refined hydrocarbon stream may be traveling as it contacts the processing equipment. In one embodiment, the corrosion inhibitor will provide a protective coating or film onto the processing equipment after at least about 5 minutes of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment. In another embodiment, the corrosion inhibitor provides a

protective coating onto the processing equipment from about 5 minutes to about 100 hours of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment. In another embodiment, a protective film or coating is formed onto the processing equipment from about 15 minutes to about 75 hours of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment. In another embodiment, a protective film or coating is formed onto the processing equipment from about 30 minutes to about 60 hours of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment. In another embodiment, a protective film or coating is formed onto the processing equipment from about 1 hour to about 50 hours of adding the corrosion inhibitor to the heavy oil in contact with the processing equipment. In another embodiment, a protective film or coating is formed onto the processing equipment from about 10 hours to about 40 hours of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment. In another embodiment, the corrosion inhibitor provides a protective coating to the processing equipment from about 12 hours to about 36 hours of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment.

[0027] Glyoxal is added to the refined hydrocarbon stream in contact with the protected processing equipment to reduce the hydrogen sulfide. Glyoxal is a water-soluble aldehyde and may include oligomers of glyoxal. Glyoxal is commercially available as a 40 weight percent aqueous solution.

[0028] The glyoxal may be added to the refined hydrocarbon stream in any conventional manner. In one embodiment, the glyoxal may be injected into the refined hydrocarbon

stream by a conventional in-line injection system and may be injected at any point in-line suitable to allow the glyoxal to mix with the refined hydrocarbon stream. The glyoxal may be added to the refined hydrocarbon stream in a continuous manner or can be added in one or more batch modes and repeated additions may be made.

[0029] The glyoxal is added to the refined hydrocarbon stream in any amount sufficient to reduce the levels of hydrogen sulfide in the refined hydrocarbon stream. In one embodiment, glyoxal may be added in an amount of from about 1 ppm to about 3000 ppm by volume, based on the volume of the refined hydrocarbon stream. In another embodiment, glyoxal may be added in an amount of from about 10 ppm by volume to about 2000 ppm by volume, based on the volume of the refined hydrocarbon stream. In another embodiment, glyoxal may be added in an amount of from about 50 ppm by volume to about 1500 ppm by volume, based on the weight of the refined hydrocarbon stream. In another embodiment, glyoxal may be added in an amount of from about 100 ppm by volume to about 1200 ppm by volume, based on the volume of the refined hydrocarbon stream.

[0030] Any amount of hydrogen sulfide in the refined hydrocarbon stream may be reduced and the actual amount of residual hydrogen sulfide will vary depending on the starting amount. In one embodiment, the hydrogen sulfide levels are reduced to 150 ppm by volume or less, as measured in the vapor phase, based on the volume of the refined hydrocarbon stream. In another embodiment, the hydrogen sulfide levels are reduced to 100 ppm by volume or less, as measured in the vapor phase, based on the volume of the refined hydrocarbon stream. In another embodiment, the hydrogen sulfide levels are reduced to 50 ppm by volume or less, as measured in the vapor phase, based on the

volume of the refined hydrocarbon stream. In another embodiment, the hydrogen sulfide levels are reduced to 20 ppm by volume or less, as measured in the vapor phase, based on the volume of the refined hydrocarbon stream.

[0031] During the production of glyoxal, acidic byproducts are formed and the glyoxal can have a pH in the range of about 2 to about 3. These byproducts can be highly corrosive. Glyoxal is water-based and after an initial dispersion throughout the refined hydrocarbon stream, will eventually settle out of the heavy oil in an aqueous phase. This aqueous phase will be very acidic and can corrode processing equipment. The coating or film formed by the corrosion inhibitor on the processing equipment protects the processing equipment and reduces or eliminates the corrosion from the acidic aqueous phase.

[0032] The corrosion inhibitor may continue to be added as the glyoxal is added to the refined hydrocarbon stream in contact with the protected processing equipment. The corrosion inhibitor will continue to deposit on the processing equipment and maintain the protection on the processing equipment. The additional corrosion inhibitor may be added in amounts of from about 1 ppm by volume to about 20 ppm by volume, based on the volume of the refined hydrocarbon stream. In another embodiment, the corrosion inhibitor may be added in an amount of from about 5 ppm by volume to about 10 ppm by volume, based on the volume of the refined hydrocarbon stream.

[0033] In one embodiment, a catalyst may be added to enhance the removal of the hydrogen sulfide. In one embodiment, the catalyst is a quaternary ammonium salt. The catalyst may be any suitable quaternary ammonium salt. In one embodiment, the catalyst has formula I:



wherein R_1 , R_2 , R_3 and R_4 are each independently an alkyl group having from 1 to 30 carbon atoms, an aryl group having from 6 to 30 carbon atoms or an arylalkyl group having from 7 to 30 carbon atoms; and X is a halide, sulfate, nitrate or carboxylate. The alkyl groups and the aryl groups may be substituted or unsubstituted.

[0034] In one embodiment, R_1 is an alkyl group having from 1 to 24 carbon atoms. In one embodiment, R_2 is an alkyl having from 1 to 24 carbon atoms, an aryl group having from 6 to 24 carbon atoms or an arylalkyl group having from 7 to 24 carbon atoms.

[0035] In one embodiment, R_3 and R_4 are each, independently, an alkyl group having from 1 to 24 carbon atoms. In another embodiment, R_3 and R_4 are each, independently, an alkyl group having from 1 to 4 carbon atoms.

[0036] The alkyl group includes, but is not limited to, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl, hexyl, decyl or dodecyl. The aryl group may be phenyl. The arylalkyl group include may be benzyl. The halide may be chloride, bromide or iodide. The sulfate may be a methyl sulfate. The nitrate may be a bisulfate nitrate. The carboxylate may be acetate.

[0037] In one embodiment, the quaternary ammonium salt is alkyl benzyl ammonium chloride or benzyl cocoalkyl (C_{12} - C_{18}) dimethylammonium chloride. In another embodiment, the quaternary ammonium salt includes, but is not limited to dicocoalkyl (C_{12} - C_{18}) dimethylammonium chloride, ditallowdimethylammonium chloride, di(hydrogenated tallow alkyl) dimethyl quaternary ammonium methyl chloride, methyl bis (2-hydroxyethyl cocoalkyl (C_{12} - C_{18}) quaternary ammonium choride, dimethyl(2-ethyl) tallow ammonium methyl sulfate, n-dodecylbenzyl dimethylammonium chloride, n-

octadecylbenzyltrimethyl ammonium chloride, n-dodecyltrimethylammonium sulfate, soya alkyltrimethylammonium chloride or hydrogenated tallow alkyl (2-ethylhexyl) dimethyl quaternary ammonium methylsulfate.

[0038] In one embodiment, the catalyst is present from about 0.01 to about 15 percent by weight based on the weight of glyoxal. In another embodiment, the catalyst is present from about 1 to about 10 percent by weight based on the weight of glyoxal.

[0039] The catalyst may be added to the refined hydrocarbon stream simultaneously with the glyoxal or may be added separately from the glyoxal. In one embodiment, the catalyst is preblended with the glyoxal before being added to the refined hydrocarbon stream.

[0040] In order that those skilled in the art will be better able to practice the present disclosure, the following examples are given by way of illustration and not by way of limitation.

EXAMPLES

EXAMPLE 1

[0041] Glyoxal is an aqueous-based compound having a pH from about 2 to about 3.

When dispersed in refined hydrocarbon streams, it will eventually settle out of the refined hydrocarbon streams into an acidic aqueous phase and settle to the bottom of processing equipment causing corrosion. To test the efficacy of the corrosion inhibitor for reducing corrosion, the corrosion test was simulated in water.

[0042] Two metal coupons of Carbon C1010 steel were weighed and added to two spindles mounted on a stirring shaft in an 800 ml Auto-Clave. The metal coupons were 180° from each other. The stirring shaft was placed into water and stirred at the

revolutions per minute as shown in Table 1. The revolutions per minute were used to calculate the approximate flow through a pipeline and are shown in Table 1. A corrosion inhibitor was added to the water at room temperature in the amounts shown in Table 1. 15 minutes later, glyoxal was injected into the water in the amounts shown in Table 1. The Auto-Clave was sealed and the water was heated to about 180°F to simulate the temperature of a typical refined hydrocarbon stream during processing. After 4 hours, the metal coupons were tested for corrosion by measuring any weight loss of the metal coupons and averaging the metal coupons.

Table 1

Sample	Glyoxal ¹ (ppm by volume)	Corrosion Inhibitor (100 ppm by volume)	RPM	Pipeline Flow (ft/min)	Weight Loss (g)	Corrosion Rate (MPY)
CE-1	None	None	450	4	0.0033	43.1
CE-2	500	5K15 ²	450	4	0.0083	110.7
I	500	5K1642 ³	450	4	0.0001	<0.5

¹Glyoxal used contains 2% by weight quaternary ammonium catalyst and is available commercially as S-1750 from GE Water.

²5K15 is a water-soluble corrosion inhibitor available commercially as Philmplus™ 5K 15 from GE Water.

³5K1642 is an organic-soluble corrosion inhibitor available commercially as Philmplus™ 5K 1642 from GE Water and containing a 3:1 by weight blend of oleic acid pyrimidine and dimer/trimer acid.

[0043] The organic soluble corrosion inhibitor shows a marked decrease in corrosion compared with the blank (sample CE-1). A water-soluble corrosion inhibitor was tested (sample CE-2), but it actually increased the corrosion.

EXAMPLE 2

[0044] Additional corrosion tests were performed on organic soluble corrosion inhibitors and were conducted in water in accordance with Example 1. Results are shown in Table 2.

Table 2

Sample	Glyoxal ¹ (ppm by volume)	Corrosion Inhibitor	Corrosion Inhibitor (ppm by volume)	Corrosion Rate (MPY)
CE-3	500	None	None	91.7
1	500	Oleic acid Pyrimidine and Dimer/Trimer Acid (3:1 wt ratio) ²	100	39.2
CE-4	500	Dimer/Trimer acid ³	25	51.8
2	500	Oleic acid Imidazoline ⁴	25	17.3
3	500	Oleic acid Imidazoline and Dimer/Trimer Acid (3:1 wt. Ratio)	24	23.3
4	500	Oleic acid Imidazoline and Hydroxyacetic acid (3:1 wt ratio) ⁵	100	14.0
5	500	Oleic acid Pyrimidine ⁶	100	10.0

¹Glyoxal used contains 2% by weight quaternary ammonium catalyst and is available commercially as S-1750 from GE Water.

²Available commercially as PhilmplusTM 5K 1642 from GE Water.

³Available commercially as Sylvadym[®] T-18 from Sylvachem Corp.

⁴Available commercially as CI-11C from GE Water.

⁵Available commercially as 5K2S from GE Water.

⁶Available commercially as 5K7 from GE Water.

[0045] The organic soluble corrosion inhibitors in Samples 1-5 show improved corrosion resistance in comparison with the blank (sample CE-3) and in comparison with an organic soluble dimer/trimer acid (sample CE-4).

EXAMPLE 3

[0046] Corrosion experiments and hydrogen sulfide scavenging were tested in a mixture of oil gas and water in an 800 ml Auto-Clave. The gas oil was initially spiked with an

approximate 0.5 wt. % solution of H₂S in kerosene before being mixed with the water. Two metal coupons of Carbon C1010 steel were weighed and added to two spindles mounted on a stirring shaft. The metal coupons were 180° from each other. The stirring shaft was placed into the gas oil and water mixture and stirred at 300 rpm. The mixture of oil gas and water was 200 ml of gas oil and 400 ml of water. The 2:1 volume ratio of water to gas oil ensured that the coupons were always immersed in water @ 300 rpm to test the corrosion in an aqueous phase. A corrosion inhibitor was added to the gas oil mixture at room temperature in the amounts shown in Table 3. 15 minutes later, glyoxal was injected into the gas oil mixture in the amounts shown in Table 3. The Auto-Clave was sealed and the gas oil and water mixture was heated to about 180°F to simulate a typical processing temperature. After 4 hours, the metal coupons were tested for corrosion by measuring any weight loss of the metal coupons, averaging the metal coupons and calculating the mils per year (MPY).

[0047] Hydrogen sulfide testing was performed using the modified ASTM 5705-95 test that measures vapor phase H₂S two hours after treatment (140°F) with Drager tubes.

Final H₂S concentration measurements are shown in Table 3.

Table 3

Sample	Glyoxal ¹ (ppm by volume)	Corrosion Inhibitor	Corrosion Inhibitor (ppm by volume)	Corrosion Rate (mpy)	Final H ₂ S (ppm)
CE-5	500	None	None	49.1	<15
1	500	Oleic acid Pyrimidine and Dimer/Trimer Acid (3:1 wt ratio) ²	100	6.67	<15

¹Glyoxal used contains 2% by weight quaternary ammonium catalyst and is available commercially as S-1750 from GE Water.

²Available commercially as Philplus[™] 5K 1642 from GE Water.

[0048] Both samples (CE-5 and 1) show removal of hydrogen sulfide while Sample 1 also shows a marked decrease in corrosion compared with the blank (sample CE-5).

[0049] While typical embodiments have been set forth for the purpose of illustration, the foregoing descriptions should not be deemed to be a limitation on the scope herein.

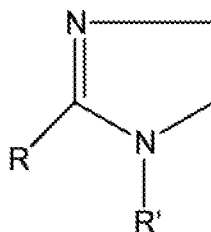
Accordingly, various modifications, adaptations and alternatives may occur to one skilled in the art without departing from the spirit and scope herein.

WHAT IS CLAIMED IS:

Having described the Invention that which is claimed is:

1. A method for reducing the amount of hydrogen sulfide present in a refined hydrocarbon stream and reducing the amount of corrosion in processing equipment contacting the refined hydrocarbon stream, said method comprising adding a corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment to protect the processing equipment and adding glyoxal to the refined hydrocarbon stream in contact with the protected processing equipment, wherein said corrosion inhibitor comprises an organic soluble compound having a nitrogen-containing ring.
2. The method of claim 1 wherein the refined hydrocarbon stream is selected from the group consisting of gas oil, naphtha, FCC slurry, diesel fuel, fuel oil, jet fuel, gasoline, kerosene and vacuum residua.
3. The method of claim 1 wherein the refined hydrocarbon stream is at an elevated temperature.
4. The method of claim 3 wherein the refined hydrocarbon stream is at a temperature of from about ambient to about 150°C.
5. The method of claim 1 wherein the processing equipment is a pipeline or a holding tank.

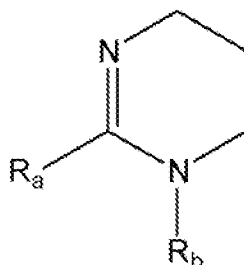
6. The method of claim 5, wherein the processing equipment is made of carbon steel.
7. The method of claim 1, wherein the corrosion inhibitor comprises a five-membered or six-membered nitrogen-containing ring.
8. The method of claim 7, wherein corrosion inhibitor is an imidazoline derivative.
9. The method of claim 8, wherein the corrosion inhibitor is a fatty acid imidazoline.
10. The method of claim 8, wherein the fatty acid imidazoline has the following structure:



wherein R and R' are each, separately, a C₆ to C₃₆ alkyl, alkylene or aromatic group.

11. The method of claim 7, wherein the nitrogen-containing ring is a pyrimidine derivative.
12. The method of claim 11 wherein the pyrimidine derivative is a fatty acid pyrimidine.

13. The method of claim 12 wherein the fatty acid pyrimidine has the following structure:



wherein R_a and R_b are each, separately, a C_6 to C_{36} alkyl, alkylene or aromatic group.

14. The method of claim 1 wherein the corrosion inhibitor is injected into the refined hydrocarbon stream.

15. The method of claim 1 wherein the corrosion inhibitor is present from about 2 ppm by volume to about 100 ppm by volume, based on the volume of the refined hydrocarbon stream.

16. The method of claim 1, wherein the corrosion inhibitor provides a protective coating onto the processing equipment after at least about 5 minutes of adding the corrosion inhibitor to the refined hydrocarbon stream in contact with the processing equipment.

17. The method of claim 1, wherein glyoxal is added to the refined hydrocarbon stream in an amount of from about 1 ppm to about 3000 ppm by volume, based on the volume of the refined hydrocarbon stream.
18. The method of claim 1, wherein the corrosion inhibitor continues to be added to the refined hydrocarbon stream after the glyoxal has been added.
19. The method of claim 18, wherein the corrosion inhibitor continues to be added in an amount of from about 1 ppm by volume to about 20 ppm by volume, based on the volume of the refined hydrocarbon stream.
20. The method of claim 1, wherein the glyoxal further comprises a catalyst.
21. The method of claim 20, wherein the catalyst is a quaternary ammonium salt.
22. The method of claim 21, wherein the catalyst has formula I:



wherein R_1 , R_2 , R_3 and R_4 are each independently an alkyl group having from 1 to 30 carbon atoms, an aryl group having from 6 to 30 carbon atoms or an arylalkyl group having from 7 to 30 carbon atoms; and X is a halide, sulfate, nitrate or carboxylate.

23. The method of claim 22, wherein the quaternary ammonium salt is alkyl benzyl ammonium chloride or benzyl cocoalkyl (C_{12} - C_{18}) dimethylammonium chloride.

24. The method of claim 21, wherein the catalyst is present from about 0.01 to about 15 percent by weight based on the weight of glyoxal.