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3,088,796

AMINE, ALCOHOL AND EMULSIFIER CORROSION INHIBITING COMPOSITION AND PROCESS

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No Drawing. Filed Dec. 14, 1960, Ser. No. 83,128
21 Claims. (Cl. 21-2.7)

The present invention relates to processes of inhibiting corrosion and preventing degradation of corrosion inhibitors, and to corrosion-inhibiting compositions.

A purpose of the invention is to minimize fouling of equipment by corrosion-inhibiting compositions.

A further purpose is to eliminate or minimize the corrosion of chemical feed lines used to feed corrosion inhibitors.

A further purpose is to increase the stability of corrosion-inhibiting compositions.

Further purposes appear in the specification and in the claims.

Film-forming primary aliphatic amines, having straight carbon chains in the range between 14 and 29 carbon atoms, have proven to be very effective as corrosion inhibitors in steam lines, condensate lines and equipment used in steam and condensate systems where an aqueous liquid or vapor is in flow. See Kahler U.S. Patent No. 2,460,259, granted January 25, 1949; Maguire U.S. Patent No. 2,712,531, granted July 5, 1955; and Gunderson U.S. Patent No. 2,767,106, granted October 16, 1956.

These primary aliphatic amines have been shown to undergo structural change when they are fed by any of the usual methods, for example as amine acetate, amine glycolate, or the like. These structural changes produce deposits which foul the equipment, increasing the downtime and decreasing the corrosion protection, since the products resulting from such structural changes are not corrosion inhibitors. The products produced by the degradation vary in composition, depending on whether polymerization, hydrolysis or some other chemical change takes place.

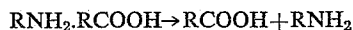
ELIMINATION OF LOWER FATTY ACID FOR DISPERSING THE AMINES—USE OF ALCOHOL AND USE OF EMULSIFIERS

A second and equally serious problem which has been encountered in the commercial application of aliphatic amines is the problem of forming suitable chemical feed dispersions. These amines are waxy and insoluble in water, and they form poor dispersions in water for feeding to steam and condensate lines and systems. The acetate or glycolate salts of the amines are soluble in water and are readily dispersible. The amine acetate, mixtures of the amine acetate and the amine, the mixtures of the amine glycolate and the amine and mixtures of acetic acid or glycollic acid and the amine have been used to produce colloiddally dispersed feeding compositions. While it is possible by such dispersions to feed the amine, these dispersions involve certain disadvantages.

It has been found that the concentrated amine acetate or glycolate or mixtures thereof undergo structural changes or degradation more readily than the amine itself. Furthermore, the amine acetate or glycolate or mixtures of the amine and the amine acetate or glycolate in con-

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centrated form corrode the chemical feed line at points of marked temperature increase where the chemical feed line enters the steam system. The cold chemical feed dispersion, as it nears the hot steam line, increases markedly in temperature. As a result of the increase in temperature, the amine acetate or glycolate or mixtures of the amine acetate and the amine, or mixtures of the amine glycolate and the amine produce free acetic or glycollic acid as follows:



The free acetic acid or glycollic acid thus formed corrodes the chemical feed line at the point of temperature increase. When the chemical feed dispersion reaches the main steam line and is diluted by the steam to the low concentration which is used in the steam line, the low concentration of acetic acid or glycollic acid present is no longer high enough to produce this undesirable corrosion, and the steam and condensate lines are thus adequately protected by the film-forming amine which is present.

The present invention is concerned particularly with minimizing or eliminating the fouling from structural changes of the film-forming amine, and eliminating or minimizing corrosion of the chemical feed line. As a result, it is possible under the present invention to obtain greater protection in the steam or condensate line and in metallic equipment which contacts the steam or the condensate.

CORROSION TESTS AT FEEDING CONCENTRATIONS

Table 1 submitted herewith shows the results of comparative tests under conditions which simulated the conditions in a steam boiler feed line as to temperature and pressure. The temperature used was 400° F. and the pressure was 262 p.s.i. The products were dissolved in distilled water and exposed for 20 hours at this temperature and pressure in contact with low carbon (AISI 1010) steel corrosion specimens.

The conditions of test in Table 1 are comparable to those at the point where the feed line enters the steam header of a boiler where corrosion of the feed line most frequently occurs.

The results in Table 1 show that water alone and the film-forming amine alone were substantially non-corrosive. Acetic acid and glycollic acid are very corrosive, exceeding 900 mils per year average penetration. The corrosion by these acids was greatly reduced when the amine was present in feed concentrations, but the rate was still too high to be tolerated under satisfactory operating conditions. All of the alcohols and the emulsifiers alone and together were substantially completely non-corrosive, and behaved in this manner whether or not the amines were present. Thus, any combination of the amines, alcohols and emulsifiers tested indicated that the combination was just as non-corrosive as the amines alone. It, therefore, is evident that feed line corrosion can be solved if lower fatty acids, having a carbon chain length of 4 or less, are eliminated, and if a combination of amine and proper emulsifier, or amine, alcohol and proper emulsifier can be used. This not only solves the problem, but it also provides an amine in end-use concentration which is more stable than the amine-acid series.

We find that the aliphatic alcohols having from 1 to 6 carbon atoms in the carbon chain and from 1 to 6 hydroxyl groups are most desirable, although very low alcohols like methyl, ethyl and isopropyl are undesirable for practical reasons because of toxicity, odor and low flash point. Dihydric alcohols like propylene glycol and diethylene glycol are very advantageous in promoting good product quality and feeding, and they have high flash points so that they do not present a fire hazard.

Higher polyhydric alcohols such as glycol, glycerol, sorbitol and pentaerythritol are also satisfactory.

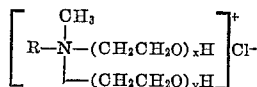
The most satisfactory film-forming amines according to our tests are octadecylamine (C_{18}), docosylamine (behenylamine) (C_{22}) and a mixture of amines composed of 25% of docosylamine (C_{22}), 30% of eicosylamine (C_{20}), 30% of octadecylamine (C_{18}), 13% of hexadecylamine (C_{16}) and 2% of tetradecylamine (C_{14}), the percentages being by weight. This mixture is referred to as "amine mixture."

Extensive tests were made with a wide variety of emulsifiers including polyoxyethylene ethers, polyoxyethylene acids, polyoxyethylene esters, polyoxyethylene alcohols, polyoxyethylene nitrogen-bearing compounds, sulphonated compounds, sulphated compounds, fatty esters, assorted nitrogen compounds, fats and the like.

It is important to stress that the emulsifier must solve two problems. First of all, it must provide from the amine or amine alcohol combinations a sufficiently good product quality for practical use in the absence of a lower fatty acid, and second it must give more stability to the amine in the end use, due to the elimination of the lower fatty acid.

NOMENCLATURE

Very excellent results were obtained with an amine salt as shown in the following formula:



Formula I

where R is a residue of a fatty acid having a carbon chain length of 10 to 29 and preferably 10 to 24 inclusive, most desirably 10 to 18 inclusive, such as a cocoanut acid residue containing C_{10} , C_{12} and C_{14} mixed fatty acid residues, an oleyl residue, or a stearyl residue and X and Y total the mol ratio of polyoxyethylene to R in the molecule and involve a mol ratio of total polyoxyethylene to R of between 2:1 and 15:1. R can be saturated or can contain one double bond in the carbon chain.

These materials are commonly referred to as Ethoquads, and are designated by an initial letter or number, a slant line and a final number. The initial letter or number designates the aliphatic group or groups which compose R as follows:

C=cocoanut acid residue, consisting of C_{10} , C_{12} and C_{14} mixed

O=oleyl residue

18=stearyl residue

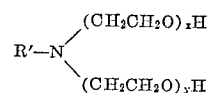
The number to the right of the slant line is the total of X+Y-10 so that Ethoquad 18/25 is of the stearyl series and has a mol ratio of $C_{18}H_{34}O$ to R of 15:1.

Typical examples of the Ethoquads are as follows:

Ethoquad C/12
Ethoquad C/25
Ethoquad O/12
Ethoquad O/15
Ethoquad O/25
Ethoquad 18/12
Ethoquad 18/15
Ethoquad 18/25

It has been found desirable in some cases to use a fur-

ther polyoxyethylene amino compound which has a formula as follows:



Formula II

where R' is a fatty acid residue having a carbon chain length of 10 to 30 and preferably 10 to 24, and the mol ratio of polyoxyethylene to R is as follows:

C series—cocoanut acids, C_{10} , C_{12} and C_{14} , ratio of polyoxyethylene to R' varies from 2:1 to 15:1.

S series—soya acids, C_{16} to C_{18} with some oleic, ratio of polyoxyethylene to R' varies from 2:1 to 15:1.

T series—tallow acids, C_{16} to C_{18} , containing some oleic, ratio of polyoxyethylene to R' varies from 2:1 to 5:1.

18 series—stearic acid, C_{18} , ratio of polyoxyethylene to R' varies from 2:1 to 50:1.

O series—oleic acid, C_{18} with one double bond, ratio of polyoxyethylene to R' varies from 2:1 to 5:1.

In this case also X+Y is the ratio of polyoxyethylene to R' in the molecule.

Other values of X+Y for other fatty acids are obtained by interpolation.

These compounds are usually called Ethomeens followed by a letter or number, a slant line and a second number. The first letter or number indicates the nature of the group R' and the second letter or number minus 10 indicates the total of X+Y, as follows:

Ethomeen C/12
Ethomeen C/15
Ethomeen C/20
Ethomeen C/25
Ethomeen S/12
Ethomeen S/15
Ethomeen S/20
Ethomeen S/25
Ethomeen 18/12
Ethomeen 18/15
Ethomeen 18/60
Ethomeen O/12
Ethomeen O/15

THE INVENTION

It has been discovered according to the present invention that extremely effective, smooth, stable dispersions can be made of filming amines as above described by utilizing one of the materials of Formula I as a dispersing agent. In the concentrated solution which is to be marketed, the filming amine will desirably make up to 30% by weight. The lower limit of the quantity of amine will be sufficient to form a film on the surfaces, which will ordinarily be 0.1% amine by weight. In the steam or water after feeding the filming amine will have a concentration up to 10 p.p.m. and preferably up to 5 p.p.m. The lower limit of the quantity of amine will be sufficient to form a film on the surfaces, which will ordinarily be 0.1 p.p.m.

The compound of Formula I used as an emulsifier will have a concentration in the concentrated solution which is fed in the range up to 10% by weight and preferably up to 5% by weight. The lower limit will involve sufficient compound of Formula I to convey the filming amine to the surfaces, usually 0.1% by weight. In the steam or water after dilution the compound of Formula I will have a concentration in the range up to 10 p.p.m., preferably up to 5 p.p.m. and most desirably up to 3 p.p.m. The lower limit will involve sufficient compound of Formula I to convey the filming amine to the surface, usually 0.1 p.p.m.

In order to produce the best results, an alcohol of the class consisting of primary and secondary aliphatic alcohols having a carbon chain length between 1 and

6 and having between 1 and 6 hydroxyl groups should be employed with the filming amine and with the emulsifier of Formula I. The alcohol will preferably be saturated. For this purpose the preferred concentration in the concentrated solution which is to be fed should be up to 10% and preferably up to 5% by weight. The lower limit will involve sufficient alcohol to convey the filming amine to the surface, usually 0.1% by weight. The concentration of the alcohol in the steam or water after dilution should be in the range up to 5 p.p.m. and most desirably up to 3 p.p.m. The lower limit will involve sufficient alcohol to convey the filming amine to the surface, usually 0.1 p.p.m.

For best results with the lowest concentration of emulsifier, it is very desirable to use the emulsifier of Formula II as a second emulsifier, preferably with the aliphatic alcohol. In this case the concentration of the emulsifier of Formula II in the concentrated dispersion which is fed will preferably be in the range up to 10% by weight and most desirably up to 5% by weight. The lower limit will involve sufficient compound of Formula II to convey the filming amine to the surface, usually 0.1% by weight. In the dilute steam or water after feeding, the concentration of emulsifier according to Formula II will be up to 10 p.p.m. and preferably up to 5 p.p.m. and most desirably up to 3 p.p.m. The lower limit will involve sufficient compound of Formula II to convey the filming amine to the surface, usually 0.1 p.p.m.

The most powerful emulsifiers are those conforming to Formula I. The compounds of Formula II are of lesser power but cooperate in an assisting role.

As will be evident from Table 2, which illustrates the abilities of the various emulsifiers to maintain stable emulsions in the concentrated emulsion and in the 5% feed solution (5% product, 95% water by weight), Ethoquad 18/25 was powerful enough to emulsify a 6% by weight octadecylamine dispersion at concentrations as low as 1% by weight, and at the same time produced very good feeding solutions. Even with concentrations of Ethoquad 18/25 as low as 0.3% by weight in the concentrated dispersion, the product quality was good but the feed in 5% by weight solution was not successful.

It will be evident from Table 2 that the use of an emulsifier of Formula I with an emulsifier of Formula II conjointly, for example Ethoquad 18/25 and Ethomeen 18/12, was highly desirable. The presence of Ethomeen 18/12 made an unsuccessful octadecylamine-Ethoquad product and feed into a successful one. The Ethomeen failed to fully recoup the quality of the product at concentrations of 0.05%, 0.1% and 0.2% by weight Ethoquad in the concentrated dispersion, but at concentrations of 0.3% by weight in the concentrated dispersion good feeds were obtained which Ethoquad alone failed to accomplish even with concentrations of 0.5% by weight.

It was particularly noticeable that the use of a compound of Formula I with a compound of Formula II was particularly attractive because the Ethomeen added body and smoothness to the mix.

At upper levels to Ethoquad up to 3% by weight, the combination with Ethomeen gave excellent products and excellent feeds which were completely stable for long periods of time. This was an outstanding feature of these emulsified products as compared with the amine-acetate and amine-glycollate series. The advantage of the products of the invention was evident in feeds and in product stability.

It was found that combinations with Ethomeen and an alcohol such as diethylene glycol made unsuccessful amine-Ethoquad products and feeds into successful ones as is shown in Table 3. For example, the 6% by weight amine-Ethoquad combination was not successful either as a mix, or as a feed where Ethoquad was under 0.5% by weight. Where Ethomeen 18/12 and diethylene glycol were successively at levels of 0.5%, 1.5% and 2.5% by

weight, mixes of 6% by weight of amine respectively with 0.1%, 0.2% and 0.3% of Ethoquad were turned into successful products and feeding solutions. At higher levels of Ethoquad, the Ethomeen and diethylene glycol did no harm, and imparted smoothness and produced very stable mixes and feeds. Tests 83 to 88 indicate that various mixtures of amine to Ethoquad, to Ethomeen, to diethylene glycol were possible indicating the flexibility in combining these materials.

A relationship exists between the components of these products. The relationship is a complex one as it depends on many features including the concentration of amine, the ratio of amine to emulsifier, such as amine to Ethoquad, and the ratio of amine to emulsifier to second emulsifier to alcohol, such as amine to Ethoquad, to Ethomeen, to diethylene glycol. As a result of hundreds of compositions made, the ranges set forth above have been determined.

The use of the two emulsifiers accomplished what one emulsifier was unable to do and the use of the two emulsifiers with the alcohol made poor products into good ones as shown in Table 3. The problem is further complicated as the ratios depend upon the power of the emulsifiers and the solvent action of the alcohols.

Emulsifiers and alcohols of the invention hold up to 30% by weight amine composition in water with additions of up to 20% of emulsifier, providing good product quality and feed.

Emulsifying power is somewhat dependent on the relative hydrophilic and hydrophobic balance. Thus, the Ethoquads of the stearyl series having a ratio of polyoxyethylene to R from 2:1 to 15:1 were excellent. Ethoquads of the oleyl series with an unsaturated carbon chain length of 18 and of the coconut series were also satisfactory.

Ethomeens of the stearyl series having a carbon chain length of 18, ranging from 18/25 to 18/60 were satisfactory over a range of polyoxyethylene to R ratios of 2:1 to 50:1. Ethomeens of the coconut series with a carbon chain length of 10:14, of the soy bean series having a carbon chain length of 16:18 with some oleyl, and Ethomeens of the tallow series having a carbon chain length between 16 and 18 and those of the oleyl series having a carbon chain length of 18 were satisfactory but required slightly higher concentrations for a given amine level.

It has been found that emulsifying and dispersing these C_{14} to C_{29} amines by emulsifiers and alcohols according to the invention in no way sacrifices corrosion protection in the end use concentrations. In fact, eliminating the lower fatty acids lowered the degradation of the amine actually while retaining the corrosion protection. Table 4 shows that the emulsifiers and alcohols do not lower the corrosion protection afforded by the amines alone. These results were obtained in the laboratory and some of the combinations have been verified in plant practice. The following compositions show some typical alcohols and emulsifiers and the flexible ratios that are possible. These all had good product quality, and gave good feeding solutions on dilution with water. The percentages are by weight.

Composition 1.—6% octadecylamine, 2% propylene glycol, 1% Ethoquad 18/25 and 91% water.

Composition 2.—6% octadecylamine, 10% propylene glycol, 10% Ethoquad 18/25, and 74% water.

Composition 3.—6% amine mixture, 2% diethylene glycol, 1% Ethomeen 18/20 and 91% water.

Composition 4.—6% amine mixture, 10% isopropyl alcohol, 2% Ethomeen 18/20 and 82% water.

Composition 5.—3% octadecylamine, 15% propylene glycol, 2% Ethoquad 18/25 and 80% water.

Composition 6.—2% amine mixture, 2% propylene glycol, 6% Ethomeen 18/12, 1% Ethoquad 18/25 and 89% water.

Composition 7.—30% amine mixture, 10% propylene glycol, 10% Ethoquad 18/25 and 50% water.

Composition 8.—6% octadecylamine, 20% diethylene glycol, 2% Ethoquad C/15, and 90% water.

Composition 9.—6% octadecylamine, 2% glycerol, 1% Ethoquad 18/25 and 91% water.

Composition 10.—10% amine mixture, 5% Ethoquad 18/25, 10% diethylene glycol and 75% water.

Composition 11.—6% amine mixture, 2% sorbitol, 1% Ethoquad 18/25 and 91% water.

Composition 12.—3% amine mixture, 4% Ethomeen C/12, 1% Ethoquad 18/25, 92% water.

Composition 13.—3% amine mixture, 4% Ethomeen S/12, 1% Ethoquad 18/25, 92% water.

Composition 14.—3% amine mixture, 4% Ethomeen 18/12, 1% Ethoquad C/15, 92% water.

Composition 15.—3% amine mixture, 4% Ethomeen O/12, 1% Ethoquad 18/25, 92% water.

Composition 16.—3% amine mixture, 4% Ethomeen T/12, 1% Ethoquad 18/25, 92% water.

Composition 17.—6% amine mixture, 2% Ethoquad 18/25, 2% Ethomeen C/15, 90% water.

Composition 18.—6% amine mixture, 2% Ethoquad 18/25, 2% Ethomeen O/12, 90% water.

Composition 19.—6% amine mixture, 2% Ethoquad 18/25, 2% Ethomeen T/12, 90% water.

Composition 20.—6% amine mixture, 2% Ethoquad 18/25, 2% Ethomeen S/20, 90% water.

Composition 21.—6% amine mixture, 2% Ethoquad O/12, 92% water.

Composition 22.—6% amine mixture, 2% Ethoquad C/12, 92% water.

Composition 23.—6% amine mixture, 2% Ethoquad O/12, 2% Ethomeen T/12, 90% water.

Composition 24.—6% amine mixture, 2% Ethoquad C/12, 2% Ethomeen S/20, 90% water.

Composition 25.—6% amine mixture, 2% Ethoquad O/15, 2% Ethomeen C/15, 90% water.

Composition 26.—6% amine mixture, 2% Ethoquad C/25, 2% Ethomeen O/12, 90% water.

In view of our invention and disclosure, variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art to obtain all or part of the benefits of our invention without copying the process and composition shown, and we, therefore, claim all such insofar as they fall within the reasonable spirit and scope of our claims.

Table 1

CORROSION TEST AT FEEDING CONCENTRATIONS

Amine	Weight, percent	Weight percent Other Ingredients	Steel Ave. P., Mils./Year
C ₁₈ -----	8	Distilled water-----	9
C ₁₈ -----	3	-----	4
-----	-----	1% acetic acid-----	3
C ₁₈ -----	8	0.8 glycollic acid-----	1,130
C ₁₈ -----	8	1% acetic acid-----	960
Amine Mixture-----	3	0.8 glycollic acid-----	140
-----	-----	-----	116
(1)-----	6	2Ethoquad 18/25-----	3
-----	-----	0.2 Ethoquad 18/25-----	2
-----	-----	2 Ethomeen 18/12, 0.2 Ethoquad 18/25-----	1
-----	-----	6 propylene glycol-----	3
Amine Mixture-----	2	2 propylene glycol, 1 Ethoquad 18/25-----	1
-----	-----	Ethoquad 18/25, 6 Ethomeen 18/12-----	1
C ₂₂ -----	5	5 propylene glycol, 1 Ethoquad 18/25-----	4
-----	-----	6 diethylene glycol-----	3
C ₁₈ -----	6	1 diethylene glycol-----	3
(2)-----	2	2 propylene glycol, 1 Ethoquad 18/25-----	2
-----	-----	2 propylene glycol, 6 Ethomeen 18/12, 1 Ethoquad 18/25-----	2

¹ Composition 1.

² Composition 6.

Table 2

Number	Weight Percent Amine Mixture	Weight Percent Ethoquad 18/25	Weight Percent Ethomeen 18/12	Product Quality of Mix	5% Feed Solution
1-----	6	0.05	-----	Poor-----	Poor.
2-----	6	0.1	-----	Fair-----	Do.
3-----	6	0.2	-----	-----	Do.
4-----	6	0.3	-----	Good-----	Do.
5-----	6	0.5	-----	-----	Do.
6-----	6	1	-----	-----	Good.
7-----	6	3	-----	-----	Do.
8-----	6	0.05	1	Poor-----	Poor.
9-----	6	0.05	3	Fair-----	Fair.
10-----	6	0.05	5	-----	Do.
11-----	6	0.1	1	-----	Do.
12-----	6	0.1	3	-----	Do.
13-----	6	0.1	5	-----	Good.
14-----	6	0.2	1	-----	-----
15-----	6	0.2	3	-----	Good.
16-----	6	0.2	5	-----	Good.
17-----	6	0.3	1	-----	Good.
18-----	6	0.3	3	-----	Do.
19-----	6	0.3	5	-----	Do.
20-----	6	0.5	1	Good-----	Do.
21-----	6	0.5	3	-----	Do.
22-----	6	0.5	5	-----	Do.
23-----	6	1	1	-----	Do.
24-----	6	1	3	-----	Do.
25-----	6	1	5	-----	Do.
26-----	6	3	2	-----	Do.
27-----	6	3	5	-----	Do.
28-----	6	3	8	-----	Do.
29-----	3	1	3	-----	Do.
30-----	5	2	5	-----	Do.
31-----	2	1	2	-----	Do.
32-----	10	3	10	-----	Do.
33-----	10	5	10	-----	Do.
34-----	3	4	3	-----	Do.

Table 3

Number	Weight Percent Amine Mixture	Weight Percent Ethoquad 18/25	Weight Percent Ethomeen 18/12	Weight Percent Diethylene Glycol	Product Quality Mix	5% Feed Solution
1-----	6	0.05	-----	-----	Poor-----	Poor.
2-----	6	0.1	-----	-----	Fair-----	Do.
3-----	6	0.2	-----	-----	-----	Do.
4-----	6	0.3	-----	-----	Good-----	Do.
5-----	6	0.5	-----	-----	-----	Do.
6-----	6	1	-----	-----	-----	Good.
7-----	6	3	-----	-----	-----	Do.
62-----	6	0.05	0.5	0.5	Fair-----	Poor.
63-----	6	0.05	1.5	1.5	-----	Good.
64-----	6	0.05	2.5	2.5	-----	Do.
65-----	6	0.1	0.5	0.5	-----	Do.
66-----	6	0.1	1.5	1.5	-----	Do.
67-----	6	0.1	2.5	2.5	-----	Do.
68-----	6	0.2	0.5	0.5	Good-----	Do.
69-----	6	0.2	1.5	1.5	Fair-----	Fair.
70-----	6	0.2	2.5	2.5	-----	Good.
71-----	6	0.3	0.5	0.5	-----	Do.
72-----	6	0.3	1.5	1.5	Good-----	Do.
73-----	6	0.3	2.5	2.5	-----	Do.
74-----	6	0.5	0.5	0.5	-----	Do.
75-----	6	0.5	1.5	1.5	-----	Do.
76-----	6	0.5	2.5	2.5	-----	Do.
77-----	6	1	0.5	0.5	-----	Do.
78-----	6	1	1.5	1.5	-----	Do.
79-----	6	1	2.5	2.5	-----	Do.
80-----	6	3	1	1	-----	Do.
81-----	6	3	2.5	2.5	-----	Do.
82-----	6	3	4	4	-----	Do.
83-----	3	1	1.5	1.5	-----	Do.
84-----	5	2	2.5	2.5	-----	Do.
85-----	2	1	1	1	-----	Do.
86-----	10	3	5	5	-----	Do.
87-----	10	5	5	5	-----	Do.
88-----	3	4	1.5	1.5	-----	Do.

Table 4

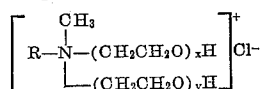
CONDENSATE CORROSION TESTS

Treatment, p.p.m.	Corrosion, Percent Protection
5 Amine Mixture-----	97
5 Amine Mixture-5 Propylene Glycol-0.9 Ethoquad 18/25-----	96
2 Amine Mixture-----	81
2 Amine Mixture-2 Propylene Glycol-.35 Ethoquad 18/25-----	85
5 C ₁₈ Amine-----	84
2 C ₁₈ Amine-----	62
2 C ₁₈ -0.2 Ethoquad 18/25-0.2 Ethomeen 18/12-----	58

Test Conditions: Two day differential tests on high carbon steel exposed to water having composition of: 150 p.p.m. CO₂ and <0.1 p.p.m. O₂ at 150-160 F. Flow rate past the specimen was 0.03 ft. per second.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. The process of protecting metal surfaces against corrosion by a flowing stream of a member of the group consisting of corrosive aqueous liquid and vapor, which comprises adding to such flowing stream a dispersion of a film-forming aliphatic primary amine having between 14 and 29 carbon atoms in the carbon chain and an emulsifier according to the following formula:

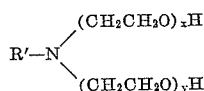


where R is a residue of fatty acid having a carbon chain length of 10 to 29, and x and y total the mol ratio of polyoxyethylene to R in the molecule and involve a mol ratio of total polyoxyethylene to R of between 5:1 and 15:1.

2. The process of claim 1, in which the amine is octadecylamine and the emulsifier referred to in claim 1 is a stearyl amine salt having a mol ratio of polyoxyethylene to R of 15:1.

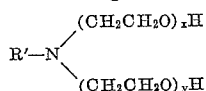
3. The process of claim 1, in which the amine is behenylamine and the emulsifier referred to in claim 1 is a stearyl amine salt having a mol ratio of polyoxyethylene to R of 15:1.

4. The process of claim 1, in which the amine is octadecylamine, the emulsifier of the formula referred to in claim 1 has R which is stearyl and has a mol ratio of polyoxyethylene to R of 15:1, which comprises adding to the liquid or vapor a second emulsifier according to the following formula:



in which R' is stearyl and the mol ratio of polyoxyethylene to R' is 2:1.

5. The process of claim 1, in which the amine is behenylamine and in the formula referred to in claim 1, R is stearyl having a mol ratio of polyoxyethylene to R of 15:1, which comprises adding to the liquid or vapor a second emulsifier according to the following formula:

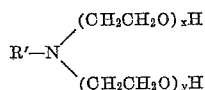


in which R' is stearyl, and which has a mol ratio of polyoxyethylene to R' of 2:1.

6. The process of claim 1, having a concentration of aliphatic primary amine between an effective amount and 10 p.p.m., and having a concentration of the emulsifier referred to in claim 1 of between an effective amount and 3 p.p.m.

7. The process of claim 1, which further comprises adding to the liquid or vapor an alcohol of the class consisting of primary and secondary polyhydric aliphatic alcohols having a carbon chain length between 2 and 6 and having between 2 and 6 hydroxyl groups.

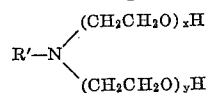
8. The process of claim 7, in which the amine is octadecylamine, the alcohol is propylene glycol, the emulsifier according to the formula previously referred to is a stearyl amine salt having a mol ratio of polyoxyethylene to R of 15:1, which comprises adding to the liquid or vapor a second emulsifier according to the following formula:



in which R' is stearyl and the mol ratio of polyoxyethylene to R' is 2:1.

9. The process of claim 7, in which the amine is behenylamine, the alcohol is propylene glycol, the emul-

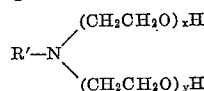
sifier of the formula above referred to is a stearyl amine salt having a mol ratio of polyoxyethylene to R of 15:1, which comprises adding to the liquid or vapor a second emulsifier having the following formula:



in which R' is stearyl and which has a mol ratio of polyoxyethylene to R' of 2:1.

10. The process of claim 7, in which the concentration of aliphatic primary amine is between an effective amount and 10 p.p.m., the concentration of the alcohol is between an effective amount and 5 p.p.m. and the concentration of the emulsifier of the formula above referred to is between an effective amount and 5 p.p.m.

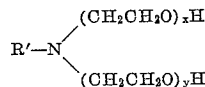
11. The process of claim 7, which comprises further adding to the liquid or vapor a second emulsifier according to the following formula:



where R' is a fatty acid residue having a carbon chain length of 10 to 30.

12. The process of claim 11, in which the concentration of primary aliphatic amine is between an effective amount and 10 p.p.m., the concentration of the emulsifier referred to in claim 1 is between an effective amount and 5 p.p.m. and the concentration of the emulsifier referred to in claim 11 is between an effective amount and 5 p.p.m.

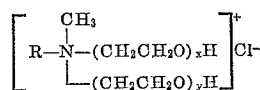
13. The process of claim 1, which comprises adding to the liquid or vapor a second emulsifier having the following formula:



where R' is a fatty acid residue having a carbon chain length of 10 to 30.

14. The process of claim 13, in which the concentration of primary aliphatic amine is between an effective amount and 10 p.p.m., the concentration of alcohol is between an effective amount and 5 p.p.m. and the concentration of the compound referred to in claim 1 is between an effective amount and 5 p.p.m. and the concentration of the compound referred to in claim 13 is between an effective amount and 5 p.p.m.

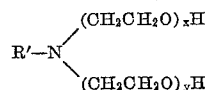
15. The process of reducing degradation of film-forming aliphatic primary amines having from 14 to 29 carbon atoms in the carbon chain, which comprises dispersing said amine in a water based dispersion by a dispersing agent according to the following formula:



where R is a residue of a fatty acid having a carbon chain length of 10 to 29, and x and y total the mol ratio of polyoxyethylene to R of between 5:1 and 15:1, while maintaining the dispersion free from fatty acid having a carbon chain length of 4 carbon atoms or below.

16. The process of claim 15, which comprises dispersing the film-forming aliphatic primary amine in the presence of an aliphatic alcohol of the class consisting of primary and secondary polyhydric aliphatic alcohols having a carbon chain length between 2 and 6 and having between 2 and 6 hydroxyl groups.

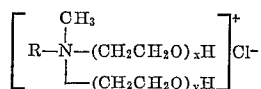
17. The process of claim 15, which comprises further adding a second emulsifier having the following formula:



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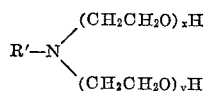
where R' is a fatty acid residue having a carbon chain length of 10 to 30.

18. A composition of matter comprising a water base, up to 30% of a film-forming primary aliphatic amine having between 14 and 29 carbon atoms in the carbon chain, up to 10% of a compound according to the following formula:



where R is a residue of a fatty acid having a carbon chain length of 10 to 29, and x and y total the mol ratio of polyoxyethylene to R in the molecule and involve a mol ratio of polyoxyethylene to R of between 5:1 and 15:1, and up to 10% of an alcohol of the class consisting of primary and secondary polyhydric aliphatic alcohols having a carbon chain length between 2 and 6 and having between 2 and 6 hydroxyl groups, there being an effective amount of each emulsifier.

19. A composition of claim 18, which also contains up to 10% of a second emulsifier according to the following formula:



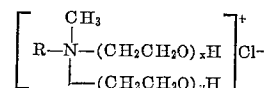
where R' is a fatty acid residue having a carbon chain length of 10 to 30, there being an effective amount present.

20. A composition of claim 19, in which the film-forming amine has a carbon chain length between 18

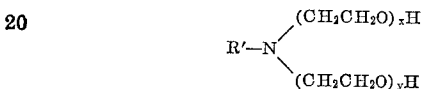
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and 22, the emulsifier referred to in claim 18 has R which is stearyl and has a mol ratio of polyoxyethylene to R of 15:1, and the second emulsifier referred to in claim 19 has R which is stearyl and has a mol ratio of polyoxyethylene to R' of 2:1 and in which the alcohol is diethylene glycol.

21. A composition essentially composed of up to 30% by weight of a film-forming amine of a class consisting of octadecylamine and behenylamine, up to 10% by weight of a compound of the following formula:



15 in which R is stearyl and x and y total the mol ratio of polyoxyethylene to R in the molecule, which mol ratio is 15:1, up to 10% by weight of an emulsifier having the following formula:



25 in which R' is stearyl and the mol ratio of polyoxyethylene to R' is 2:1, balance water, there being an effective quantity of each emulsifier.

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