METHOD OF PROTECTING METAL SURFACES FROM CORROSION AND CORROSION INHIBITOR COMPOSITIONS

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This invention relates to a method of protecting metal surfaces from corrosion and to corrosion inhibitor compositions.

It is a general object of this invention to provide a novel method for protecting metal surfaces from corrosion involving the use of a class of corrosion inhibitors whose unexpectedly superior corrosion inhibiting properties were discovered in the course of the experimental work leading to the present invention. More specifically, it is an object of this invention to provide a method and a means for protecting inhibitors under adverse conditions against corrosion by the action of oxygen and water. In this connection, it is an object of this invention to provide a corrosion inhibiting method which is capable of protecting ferrous metal surfaces which are normally in contact with atmospheric air, and also ferrous metal surfaces which are normally or at least periodically in contact with liquids containing dissolved water, oxygen and other corrosive compounds or elements. It is a still further object of this invention to provide corrosion inhibitor compositions for use in the method of this invention, and particularly corrosion inhibitor compositions in which the liquid or solid carrier for the corrosion inhibitor cooperates with the inhibitor to increase its effectiveness in protecting metal surfaces, and particularly ferrous metal surfaces. Further objects and advantages will become apparent as the specification proceeds.

It is well-known that the corrosion of metal surfaces and especially ferrous metal surfaces by the action of oxygen and water is a serious problem. One method of protecting metal surfaces against corrosion involves the treating of the surfaces with a corrosion inhibitor adsorbed onto the metal surface and forming a protective film thereon. The mechanism of action of corrosion inhibitors of this type is not entirely understood, although a number of theories have been advanced. It is known that in general organic polar compounds are adsorbed on metal surfaces, and that when adsorbed on metal surfaces they provide at least a small measure of protection for the metal surfaces. However, polar compounds differ widely in their effectiveness as corrosion inhibitors, and it is not possible in the present state of knowledge to predict that a particular organic polar compound will be an effective corrosion inhibitor under conditions of practical use. Thus, the search for better corrosion inhibitors, which is a continuing one, must necessarily be conducted largely on an empirical basis. It was therefore surprising to discover that a class of compounds appeared as a preferred group within this class are highly effective corrosion inhibitors under adverse conditions of use, even though a much smaller amount of the inhibiting agent is employed than has generally been thought necessary with other comparable inhibiting agents.

It has been discovered that the class of compounds represented by the following structural formula can be used to effectively inhibit the corrosion of metal surfaces such as ferrous metal surfaces and to substantially ac-
agents is greatly increased when the compounds are employed in the form of their fatty or resin (rosin) acid salts. Salts of the character desired are simple to prepare. All that is required is that a polyamine of the type described above be mixed in the liquid phase (generally above 50°C) with fatty or resin acids. An exothermic neutralization reaction then ensues and the temperature of the reaction is preferably kept below about 100°C. The reaction products will be salts of the polyamines. At temperatures much above 100°C, the formation of amides will become excessive. When the polyamine compound is a diamine containing a primary and secondary group as preferred, it can combine with 2 resin or fatty acid molecules. Since the secondary nitrogen is more basic than the primary nitrogen, the first molecule of the acid will probably react with the secondary nitrogen, while the second molecule will react with the primary nitrogen. Therefore, it is preferred to use about 1 to 2 moles of fatty or resin acids to each mole of diamine. For example, if a 2 to 1 molar ratio of acid to amine is employed, the resulting compounds will be of the type represented by the following structural formula:

\[
\begin{align*}
\text{R}^\prime - \text{NH}^2 \text{NR} - (\text{CH}_2\text{X}) \text{NR}_2 - \text{O} - \text{O} - \text{R}^\prime
\end{align*}
\]

wherein \( \text{R}^\prime \) and \( \text{X} \) have the meaning previously assigned, and \( \text{R}'' \) is an alkyl, alkenyl, or alicyclic radical containing from 6 to 22 carbon atoms.

In preparing the diamine salts of the type illustrated in the above formula, either separate resin or fatty acids can be used, or mixtures thereof. Naturally occurring mixtures such as those found in tall oil are particularly suitable.

It will be noted that the amine salts of the type illustrated by the formula above have cationic and anionic portions. The cationic portion is the N-alkyl or N-alkenyl or N-alkycyclic substituted polymethylene diamine residue with one or more additional hydrogen atoms, while the anionic portion consists of one or more fatty or resin acid molecules with the acid hydrogen removed. The fatty acid salts, and particularly the unsaturated \( \text{C}_n \) fatty acids such as oleic and linoleic, are preferred to the resin acid salts. However, good results are obtained with tall oil resin acid salts, and also mixtures of tall oil and fatty acid salts. When more than about 2 moles of the fatty or resin acids are reacted with one mole of the polymethylene diamine, the reaction will not go to completion. Since fatty and resin acids are in themselves slightly corrosive to metal surfaces such as ferrous metal surfaces, it is preferred to form the amine salt by reacting slightly less than two moles of acid to each mole of amine. However, the dieic acid salt is preferred to the mono-acid salt, and therefore it is advisable to use substantially more than 1 mole of acid to each mole of diamine. Specific compounds which have been found to be excellent corrosion inhibitors for ferrous metal surfaces are: N-hexadecyl-trimethylene diamine mono-oleate, N-hexadecyl-trimethylene diamine mono-octolate, N-octadecyl-trimethylene diamine mono-octoleate, N-tallow-trimethylene diamine mono-oleate, N-tallow-trimethylene diamine mono-octoleate, N-soya-trimethylene diamine mono-oleate, and N-soya-trimethylene diamine mono-octoleate. The oleic acid salts of the diamines are particularly advantageous because red oil (commercial grade oleic acid) is readily available and inexpensive raw material. Furthermore, the employment of an unsaturated \( \text{C}_n \) fatty acid such as oleic acid tends to increase the solubility of the amine salts in oils which is desirable when the inhibiting agents are applied in oil carriers to the metal surfaces.

Either the diamines themselves or the diamine fatty or resin acid salts as described above can be used to inhibit corrosion of metal surfaces. In general, all that their use requires is that they be applied to the metal surfaces in such a way as to form an adsorbed protective film on the metal surface. Since the commercial forms of most of the diamines and diamine salts falling within the scope of this invention are normally paste-like solids, it is possible to apply them directly to the metal surfaces in solid form by spreading them over the metal surfaces to be protected. The temperature of the reacting the metal surfaces with the treating agent. However, this method of applying the compounds of this invention is relatively wasteful, since corrosion inhibitors are usually added to the corrosive environment in small quantities. The inhibiting agents are preferably applied in a liquid carrier in which they are nearly amine soluble and insoluble in the solvents which are suitable for this purpose include crude oil and petroleum distillates such as gasoline, kerosene, xylenes, benzene, lubricating oils, etc. In general, where the metal surface is normally exposed to the atmosphere, it is preferred to apply the inhibiting agents by dissolving them in a non-polar solvent of relatively low volatility, since it has been found that non-polar solvents of low volatility cooperate with the treating agent in protecting the metal surface. Hydrocarbon oils such as those employed as protective oils (slashing oils) are excellent for this purpose. In general, hydrocarbon oils of this type have a relative high viscosity, say from S. A. E. 20 to 80. The inhibiting agents of this invention can also be advantageously incorporated in hydrocarbon greases of the types employed both for protective and lubricating purposes. Gelled hydrocarbon oil greases containing bentonite or derivatives thereof can also be combined with the treating agents of this invention. Where liquids are stored in tanks or passed through pipe lines, etc. and are fairly continuously in contact with the metal surfaces of the tank walls or the pipe lines, effective inhibition of corrosion can be obtained even though the liquid in contact with the surfaces and in which the inhibiting agents are dissolved is a polar solvent such as alcohol, or is a non-polar solvent of high volatility such as gasoline. In some solvents, such as water, the inhibiting agents are not sufficiently soluble to permit the formation of protective films on metal surfaces by dissolving the inhibiting agents in the solvents. However, if desired emulsions of the treating agents in the water and other solvents in which the treating agents are not soluble can be employed.

The amount of inhibiting agent which should be incorporated in the liquid carrier, preferably by dissolving therein, can be varied widely. In general, a sufficient amount of the inhibiting agents of this invention should be dissolved in the liquid carrier to form a continuous film on the metal surface to be protected. Efficient results have been obtained by incorporating as little as 0.1% by weight of the inhibiting agent in the liquid carrier. For example, the dissolving of at least 0.1% by weight and preferably 0.5% by weight of the inhibiting agents of this invention in hydrocarbon oils which are contacted with ferrous metal surfaces for either lubricating or protective purposes has been found to almost completely prevent corrosion due to the action of water and oxygen. For use in protective hydrocarbon oils, good results are obtained for most purposes by incorporating from about 0.1% to 0.5% of the treating agents in the protective oils. Using a greater quantity of the treating agents in liquid carriers such as hydrocarbon oils, gasoline, etc. does not generally produce any better protective action, but does not interfere with the protective action. Therefore, if desired the agents may be added to the particular solvent to the limit of their solubility if desired. For use in lubricating and protective greases composed mainly of a gelled hydrocarbon oil, it is generally desirable to use a somewhat higher proportion of the inhibiting agents. In general, from about 1 to 5% by weight of the treating agents in the grease is desirable. However, it has been found that even bentonite greases which are susceptible to breaking of the gel by polar compounds, are fully compatible with the treating agents of this invention up to as much as a 50-50 mixture of the grease and the inhibiting agent.
This is surprising in view of the fact that other amine type inhibiting agents are known to break the gel of bentonite greases at concentrations as low as .1 to 1%. It can be stated in general that if the inhibiting agent is not soluble in the liquid carrier at least to .01 percent by weight, and preferably to .001 percent by weight that an effective protective film can probably not be formed on metal surfaces with the particular liquid carrier, unless special protective measures are taken such as emulsifying the agents in the carrier.

Adsorption type corrosion inhibitors are believed to act by the formation of a diffusion barrier on the metal surface. It is further believed that the diffusion barrier prevents or retards the diffusion of ions or molecules of the corrosive environment toward the metal surface, or prevents or retards the diffusion of metal ions into the environment. However, the exact nature of the diffusion barrier, and of its method of operation is not well understood. Experimental work leading to the present invention brought to light a number of factors which would seem to be important. It was found that the presence of two polar groups in the inhibiting agent are desirable. The adsorptive contact of both polar groups with the metal surface apparently produces a blocking effect due to the portion of the molecule inhibiting agent between the two polar groups. However, not all polar groups are tenaciously enough adsorbed by ferrous metal surfaces to accomplish this result, and there appears to be a further requirement for obtaining this effect that the groups be arranged in a particular way in the molecular structure. The secondary amine polar group, and the amine-acid polar group which are present in the inhibiting agents of this invention are found to be particularly effective in forming films which tenaciously adhere to the ferrous metal surfaces. Further, the presence of the polyethylene groups between the secondary amine polar group and the amine acid polar group was found to give the desired blocking effect. Molecular models of the trimethylene diamine group of inhibitors were constructed, and it was found that both of the polar groups could probably be adsorbed on the metal surface while allowing the diamine molecule to retain a strain-free configuration. It is further believed that the effectiveness of the compounds of this invention is due in part to the fact that the portion of the molecule extending between the two polar groups is a straight chain hydrocarbon group or specifically a polylethylene group such as a trimethylene group. This would seem to permit close packing of the molecules attached to the metal surface, which in turn is believed to produce a special orientation of the molecules into a crystal-like structure. Thus, the polyethylene portions of the molecules tend to block the metal surface, while the long chain fatty or resin acid groups attached to each of the polar groups are oriented approximately normal to the surface. Apparently, corrosion inhibition is related to close packing and orientation of the molecules of the inhibiting agent. Another way of stating this is that the effectiveness of a diffusion barrier on a metal surface increases as its structure tends toward that of a "planar crystal."

The inhibiting agents falling within the scope of this invention, particularly the trimethylene group, are believed to have molecular structures which permit the maximizing of the desirable effects of close packing and orientation of the molecules within the adsorbed protective film. However, it has been found that the "planar crystal" films can be made still more effective as diffusion barriers by the action of a solvent and particularly a non-polar solvent which cooperates with the inhibiting agents. It is believed that non-polar solvent molecules become oriented between the outwardly extending hydrocarbon chains of the inhibitor and are held there more or less firmly due to the Van der Waals' forces between the hydrocarbon chains, thus completing the close packed "planar crystal." If the non-polar solvent used as a liquid carrier for the treating agents is highly volatile, the protective film will be impaired by the evaporation of the solvent molecules from within the "planar crystal" structure on exposure of the coated metal surface to the atmosphere. Therefore, it is preferred that relatively non-volatile, non-polar solvents be employed, as indicated above, such as hydrocarbon oils, when the metal surface is normally exposed to the atmosphere. In other words, the mechanism by which for example N-tallow-trimethylene diamine dichloroacetate in a protective oil inhibits corrosion is believed to consist of the following steps:

(1) Adsorption of the diolate from the oil solution onto the metal surface so as to form an oriented, close packed "planar crystal," and (2) Incorporation of the hydrocarbon oil molecules of the solvent into the spaces between the hydrocarbon chains in the "planar crystal," whole forming a diffusion barrier which is firmly bonded to the metal surface.

For the purpose of demonstrating the effectiveness of the corrosion inhibiting agent of this invention in accomplishing the stated objectives, it is desired to set out the following examples reporting actual tests of the inhibiting agents.

Example I

N-tallow-trimethylene diamine, N-tallow-trimethylene diamine mono-oleate, and N-tallow-trimethylene diamine diolate were subjected to the water drop corrosion test described by Baker and Zisman in Ind. Eng. Chem., 41, 137 (1949).

The static water drop corrosion test as adapted consisted of immersing a polished test coupon of 3. A. E. 1020 steel in an inhibited oil, allowing one hour for thermal and adsorption equilibria to be attained. A drop of water (0.2 ml.) was then placed in a cup-like depression in the test coupon by means of a capillary pipet. The test coupon remained immersed in the oil during this operation. The coupon remained undisturbed at the test temperature (140° F.) for 48 hours. At the end of this period the coupons were inspected for visible signs of corrosion. If there were any indications of rusting, staining or pitting the test was classed as having failed. In each case the oil used as the solvent for the inhibitor was U. S. P. light white mineral oil. In replicate tests it was found that as little as .015 percent by weight of both N-tallow-trimethylene diamine mono and diolates inhibited the oil sufficiently so that it passed the test. The point at which significant failure of corrosion inhibition was noted for these two compounds was about .008 percent by weight. Good results were also obtained with N-tallow-methylene diamine, and no significant failure was noted down to about .0125 weight percent. It is particularly noteworthy that the effective concentration of 0.015 weight percent of the fatty acid-amine salts tested are considerably smaller than the concentrations normally required for effective corrosion inhibition.

Example II

The duration of the static water drop corrosion test was lengthened to 168 hours. Various concentrations of N-tallow-trimethylene diamine mono and diolates in hydrocarbon oils were subjected to the longer period of testing. Uninhibited hydrocarbon oils of the same type were also tested. The test coupons were observed through a window in the constant temperature cabinet which was employed in the test. It was found that rusting of the coupons in hydrocarbon oils inhibited with less than 0.01 weight percent of the diamine oleates occurred in 15 to 30 minutes. This was also the time required for rust to appear on the coupons immersed in uninhibited oils. If, however, as the weight percent of the inhibiting agents in the oils were increased to about .015 weight percent, there was no corrosion after 168 hours of testing. In other words, if rusting did not occur within the first half hour of the test, the anti-corrosion effect was greatly prolonged. This would seem to be strong evidence for the
“planar crystal” theory and other of the theoretical considerations discussed above.

Example III

A mild steel coupon was immersed in a 0.2 weight percent solution of N-tallow-trimethylene diamine oleates in petroleum ether and allowed to stand for 30 minutes. The coupons were then removed and the solvent evaporated. A drop of water placed on the coupon caused rusting in an approximately same length of time as required for rusting on a control coupon. When, however, a non-volatile, non-polar solvent, such as white mineral oil was employed as the liquid carrier for the inhibiting agents, there was no rusting. The data and figures above discussed the theoretical considerations discussed above.

Example IV

Test coupons which have been used in the static water drop corrosion test of Example II were removed from the inhibited oils and excess oil removed with a dry cloth to facilitate inspection for rusting, staining or pitting. These coupons were then set aside, and stored in contact with the atmosphere. Several months later it was noted that the coupons which had been in the N-tallow-trimethylene diamine oleate inhibited oils were completely free of corrosion as compared with other coupons which showed varying stages of corrosion. It was also noted that those coupons which had been in the inhibited oils could not be stained by fingerprints.

The tests and reported observations in Examples III and IV indicate that the solvent has a definite function in the protection of the metal surfaces by the inhibiting agents of this invention. The possible mechanism of this cooperative action between the solvent and the inhibiting agents has been discussed above. When the metal surface is normally exposed to the atmosphere, the cooperative action between the treating agent and the liquid carrier used to form the film of the inhibiting agent on the metal surface reaches a maximum when the liquid carrier or solvent is of the non-polar type and of low volatility. However, it was also found that some cooperation of the type described exists between the inhibiting agents of the invention and polar solvents such as ethyl alcohol when such solvents containing the dissolved inhibiting agents are continuously in contact with the metal surfaces.

The foregoing specification there has been set forth specific embodiments of this invention for purposes of illustration, it will be apparent to those skilled in the art that many of the specific embodiments and details thereof can be varied widely without departing from the spirit of this invention.

We claim:

1. The method of inhibiting corrosion of a ferrous metal surface, comprising forming an adsorbed protective film on said metal surface of the salt reaction product of a polyamine compound with an acid, said polyamine compound containing at least 2 amine groups in its molecular structure connected by a polyethylene group having from 2 to 6 methylene groups, one of said amine groups being connected to a radical selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and allylic radicals derived from the resin acids, said acid reacted with said polyamine compound to form a salt thereof being selected from the group consisting of fatty and resin acids having from 6 to 22 carbon atoms.

2. The method of inhibiting corrosion of a ferrous metal surface comprising forming an adsorbed protective film on said metal surface of the salt reaction product of a polyamine compound with an acid, said polyamine compound including in its molecular structure at least 2 amine groups connected by the trimethylene group, one of said amine groups being connected to a radical selected from the group consisting of allylic radicals derived from fatty acids having from 8 to 22 carbon atoms and allylic radicals derived from the resin acids, said acid reacted with said polyamine compound to form a salt thereof being selected from the group consisting of fatty and resin acids having from 6 to 22 carbon atoms.

3. The method of inhibiting corrosion of a ferrous metal surface, comprising dissolving at least 0.1 percent by weight of the salt reaction product of a diamine and an acid in a non-polar solvent, said diamine including in its molecular structure a trimethylene group extending between said amine groups and having one of its amine groups connected to a radical selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and allylic radicals derived from fatty acids having from 6 to 22 carbon atoms, said acid reacted with said diamine to form a salt thereof being selected from the group consisting of fatty and resin acids containing from 6 to 22 carbon atoms, and then contacting said metal surface with said solvent containing said reaction product to deposit a protective film thereon of said reaction product.

4. The method of inhibiting corrosion of a ferrous metal surface, comprising dissolving at least 0.15 percent by weight of the salt reaction product of a diamine and an acid in a hydrocarbon oil, said diamine having a trimethylene group extending between the amine groups therein and having a fatty acid radical containing from 14 to 18 carbon atoms attached to one of the amine groups therein, said acid reacted with said diamine to form a salt thereof being selected from the group consisting of fatty and resin acids containing from 6 to 22 carbon atoms, and then contacting said ferrous metal surface with said hydrocarbon oil containing said reaction product to deposit a protective film thereon of said reaction product, whereby molecules of said hydrocarbon oil are also incorporated in said protective film.

5. The method of inhibiting corrosion of a ferrous metal surface, comprising dissolving at least 0.1 percent by weight of an N-tallow-trimethylene diamine oleate in a non-polar solvent, and then contacting a ferrous metal surface with said solvent containing said oleate to deposit a protective film thereon of said oleate.

6. The method of inhibiting corrosion of a ferrous metal surface, comprising dissolving at least 0.15 percent by weight of an N-tallow-trimethylene diamine oleate in a hydrocarbon oil, and then contacting a ferrous metal surface with said oil containing said oleate to deposit a protective film thereon of said oleate, whereby molecules of said hydrocarbon oil are also incorporated in said protective film.

7. The method of inhibiting corrosion of a ferrous metal surface normally exposed to the corrosive action of the atmosphere, comprising dissolving at least 0.1 percent by weight of an N-tallow-trimethylene diamine oleate in a non-polar solvent of low volatility to form a protective treating solution, and then applying said treating surface to a ferrous metal surface to form a film thereon containing molecules of said solvent in closely bound association with the molecules of said oleate, and then exposing said metal surface to the atmosphere with said protective film thereon.

8. A composition for use in controlling corrosion of metal surfaces, comprising a protective hydrocarbon oil having dissolved therein at least 0.1 percent by weight of the salt reaction product of a diamine compound with an acid, said diamine compound having a trimethylene group extending between the amine groups therein and having a radical connected to one of the amine groups selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and allylic radicals derived from the resin acids, said acid reacted with said diamine compound to form a salt thereof being selected from the group consisting of fatty and resin acids having from 6 to 22 carbon atoms.

9. A composition for use in controlling corrosion of metal surfaces comprising a protective hydrocarbon oil
having dissolved therein at least 0.015 percent by weight of an N-tallow-trimethylene diamine oleate.

10. A composition for use in controlling corrosion of metal surfaces, comprising a protective hydrocarbon grease containing at least 1 percent by weight of the reaction product of a diamine and an acid, said diamine including a trimethylene group extending between the amine groups therein and having a radical attached to one of the amine groups selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and alicyclic radicals derived from rosin acids, said acid reacted with said diamine to form a salt thereof being selected from the group consisting of fatty and rosin acids having from 6 to 22 carbon atoms.

11. A composition for use in controlling corrosion of metal surfaces, comprising a protective grease composed mainly of a gelled hydrocarbon oil in admixture with at least 1 percent by weight of an N-tallow-trimethylene diamine oleate.

12. The method of inhibiting corrosion of a metal surface, comprising dissolving at least .01% by weight of the salt reaction product of a polycrystalline compound with an acid in a hydrocarbon oil, said polycrystalline compound containing at least 2 amine groups in its molecular structure connected by a polymethylene group having from 2 to 6 amine groups in its molecular structure connected by a polymethylene group having from 2 to 6 amine groups being connected to a radical selected from a group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and alicyclic radicals derived from rosin acids, said acid reacted with said polycrystalline compound to form a salt thereof being selected from the group consisting of fatty and rosin acids containing from 6 to 22 carbon atoms.

13. A composition for use in controlling corrosion of metal surfaces, comprising a protective hydrocarbon oil having dissolved therein at least .01% by weight of the salt reaction product of a polycrystalline compound with an acid, said polycrystalline compound containing at least 2 amine groups in its molecular structure connected by a polymethylene group having from 2 to 6 amine groups in its molecular structure connected by a polymethylene group having from 2 to 6 amine groups being connected to a radical selected from a group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and alicyclic radicals derived from rosin acids, said acid reacted with said polycrystalline compound to form a salt thereof being selected from the group consisting of fatty and rosin acids containing from 6 to 22 carbon atoms.

14. The method of inhibiting corrosion of a metal surface, comprising forming an adsorbed protective film on said metal surface of the salt reaction product of a polycrystalline compound containing at least 2 amine groups in its molecular structure connected to a radical selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and alicyclic radicals derived from rosin acids.

15. The method of inhibiting corrosion of a metal surface, comprising forming an adsorbed protective film on said metal surface of the salt reaction product of a polycrystalline compound with an acid, said polycrystalline compound containing at least 2 amine groups in its molecular structure connected to a radical selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and alicyclic radicals derived from rosin acids, said acid reacted with said polycrystalline compound to form a salt thereof being selected from the group consisting of fatty and rosin acids containing from 6 to 22 carbon atoms.

16. The method of inhibiting corrosion of a metal surface, comprising forming an adsorbed protective film on said metal surface of the salt reaction product of a polycrystalline compound and a fatty acid, the alkyl group of said diamine containing from 14 to 18 carbon atoms, said fatty acid containing from 6 to 22 carbon atoms.

17. The method of inhibiting corrosion of a ferrous metal surface, comprising dissolving about .05 to .3% by weight of the salt reaction product of an N-alkyl-trimethylene diamine and a fatty acid in a non-polar solvent, the alkyl group of said diamine containing from 14 to 18 carbon atoms, said fatty acid containing from 6 to 22 carbon atoms, and then contacting said ferrous metal surface with said solvent containing said reaction product to deposit a protective film thereon of said reaction product.

18. The method of inhibiting corrosion of a metal surface, comprising forming an adsorbed protective film on said metal surface of the salt reaction product of a polycrystalline compound with an acid, said polycrystalline compound containing at least 2 amine groups in its molecular structure connected by a polymethylene group having from 2 to 6 amine groups in its molecular structure connected by a polymethylene group having from 2 to 6 amine groups being connected to a radical selected from the group consisting of aliphatic radicals derived from fatty acids having from 8 to 22 carbon atoms and alicyclic radicals derived from rosin acids, said acid reacted with said polycrystalline compound to form a salt thereof being selected from the group consisting of fatty and rosin acids containing from 6 to 22 carbon atoms.

19. The method of claim 18 in which said polycrystalline compound is a trimethylene diamine compound, and in which said carboxy-hydrocarbon is an aliphatic carboxy-hydrocarbon.

20. The method of claim 18 in which said polycrystalline compound is a trimethylene diamine compound, and in which said carboxy-hydrocarbon is an aliphatic carboxy-hydrocarbon.

References Cited in the file of this patent

UNITED STATES PATENTS

2,244,712 Kyrides ------------------ Jan. 10, 1941
2,267,204 Kyrides ------------------ Dec. 23, 1941
2,400,785 Rust ---------------------- May 21, 1946
2,532,277 Castle --------------------- Dec. 5, 1950
2,664,422 Barium ------------------- Aug. 14, 1951
2,568,876 White et al. -------------- Sept. 25, 1951
2,638,450 White ------------------- May 12, 1953

OTHER REFERENCES