

PATENT SPECIFICATION

(11) 1 604 526

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- (21) Application No. 19157/78 (22) Filed 12 May 1978
 (31) Convention Application No. 797083
 (32) Filed 16 May 1977
 (31) Convention Application No. 862691
 (32) Filed 27 Dec. 1977 in
 (33) United States of America (US)
 (44) Complete Specification published 9 Dec. 1981
 (51) INT CL³ A01N 57/00
 (52) Index at acceptance

C1B 3F1
 ASE 311 316 504 506 507 G

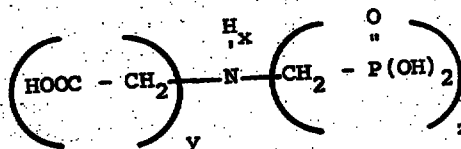


(54) CORROSION INHIBITED AGRICULTURAL COMPOSITIONS

(71) We, MONSANTO COMPANY, a corporation organised under the laws of the State of Delaware, United States of America, of 800 North Lindbergh Boulevard, St. Louis, Missouri 63166, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the inhibition of metallic corrosion by aqueous agricultural compositions containing as an active agricultural ingredient an aminomethylenephosphonic acid, or an agriculturally acceptable salt or ester derivative thereof. More particularly, this invention relates to the inhibition of corrosion of iron or zinc surfaces contacted by aqueous agricultural compositions wherein the active agricultural ingredient, an aminomethylenephosphonic acid, or salt or ester derivatives thereof in the presence of water and in the absence of an inhibitor is corrosive of such surfaces and evolves hydrogen gas. According to this invention, corrosion of iron or zinc surfaces is inhibited by the inclusion in such agricultural composition of a corrosion inhibiting amount of a thiol compound or salt thereof as hereinafter described.

The aminomethylenephosphonic acids employed in the compositions of this invention are encompassed by the following formula



wherein y and z are each individually 1 or 2, and x is 0 or 1, the sum of x, y and z being 3. Also useful in the compositions of this invention are the agriculturally acceptable salts and esters of these acids.

The term "agricultural composition" as herein employed includes within its scope herbicidal and plant growth regulant compositions. While such compositions are frequently formulated as dry powder compositions and used in this form to dust plant foliage, more commonly they are formulated into solutions, emulsions, suspensions or dispersions for wet application to plant foliage. These liquid formulations usually contain water and more water is added thereto at the time of application in order to dilute the concentration of the active ingredient in the formulation to levels enabling the application of predetermined, controlled amounts to plant foliage. Normally, the dry powder formulations are generally non-corrosive of metal surfaces whereas depending on the specific active ingredient in an aqueous liquid formulation and the surface-active agent which may also be present in the formulation, mild to severe corrosion of metal surfaces will occur when contacted by the aqueous agricultural compositions.

The term "active agricultural ingredient" as herein employed is inclusive of any ingredient functioning as a plant phytotoxicant or as a plant growth regulant. The particular function of an active ingredient can be that of a herbicide when

applied to the plant at moderate to high application rates and, on the other hand, function as a plant growth regulant at low to minute application rates. Such dual function capability is exhibited by some of the aminomethylenephosphonic acids and their agriculturally acceptable salts as described in U.S. Patents 3,455,675 and 3,556,762, the former being directed to phytotoxicant use and the latter to plant growth regulation. The herbicidal activity of N-phosphonomethylglycine and its agriculturally acceptable salt and ester derivatives is described in U.S. Patents 3,799,758; 3,868,407; 3,971,648 and 3,977,860. Plant growth regulant utility for N-phosphonomethylglycine and its agriculturally acceptable salt and ester derivatives is described in U.S. Patents 3,853,530 and 3,988,142.

The aqueous formulations of the aminomethylenephosphonic acids, such as N-phosphonomethylglycine or derivatives thereof, and more particularly those formulations water-diluted to application levels are corrosive to iron, steel or galvanized metal surfaces of containers in which the concentrates or mixtures are stored, and to steel or galvanized surfaces of spraying equipment. Hydrogen evolution is one aspect of the corrosion activity and can cause disruptive pressures in closed containers containing the aqueous agricultural compositions as well as constituting a fire hazard and explosion hazard.

It is known that the application of various organic coatings, such as the phenolics, synthetic rubbers, alkyds, vinyls as well as glass linings to metal surfaces is one practical means for protecting or preventing corrosion of metal surfaces but such coatings increase the cost of containers and other equipment used for application of herbicides or plant growth regulants. Moreover, the integrity of such coatings is subject to accidental or abrasive abuse under agricultural application working conditions whereby the coating is mechanically abraded, scraped or otherwise detached from the metal surface. When this occurs, the exposed metal surface is then readily attacked by the agricultural composition, and such corrosion frequently causes detachment or degradation of the protective coating material adjacent to the exposed metal surface thus accelerating the overall corrosion of the equipment.

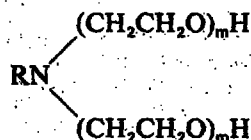
Trabanelli et al reported on the performance of various organic sulfur compounds for inhibiting corrosion of iron immersed in sulfuric acid and noted that mercaptans were generally poor inhibitors of iron corrosion and in some instances even functioned as corrosion stimulators (Chemical Abstracts, Volume 72, page 206, 58134z).

It was thus most surprising to discover that thiol compounds, e.g. mercaptans, as well as the ammonium and alkali metal thio salts of inorganic polybasic acids and the thio alkali metal salts are effective inhibitors of metal corrosion for aqueous agricultural compositions containing as an active agricultural ingredient an aminomethylenephosphonic acid, such as N-phosphonomethylglycine or the agriculturally acceptable salt or ester derivatives thereof. Obviously, a satisfactory inhibitor of acidic corrosion as measured by H_2 evolution and metal corrosion rate for a herbicidal composition or plant growth regulant composition should not deleteriously modify the agricultural activity of the composition. It was found that both retention of agricultural activity and adequate inhibition of acidic corrosion was obtained by the addition to aqueous formulations of an aminomethylenephosphonic acid or the agriculturally acceptable derivatives of relatively small amounts of certain thio compounds, such as the alkane thiols and dithiols, alkali metal salts of the alkane thiols and dithiols, and the ammonium and alkali metal thio salts of polybasic inorganic acids, i.e., sulfuric acid and phosphoric acid. Adequate inhibition of acidic corrosion as measured by H_2 evolution can be obtained with a minimum of 0.15 percent, by weight of the thio compound on the weight of N-phosphonomethylglycine. To insure long term corrosion inhibition, it is preferred to use the thio compound in amounts of 0.3 to 3 percent by weight on the weight of the N-phosphonomethylglycine or aminomethylenephosphonic acid or derivatives thereof although the thio compound can be employed in amounts as high as 20 percent by weight based on the N-phosphonomethylglycine. Not too infrequently, aqueous concentrates of the herbicidal or plant growth regulant compositions may be stored in the vendor's metal containers by the farmer for many months before being used and, hence, it is desirable to minimize corrosion of the container to the maximum extent in order to prevent any possible leakage of the concentrate due to rusting of the container's metal walls. Amounts more than 5 percent by weight of the thio compound can be used if desired but no further commensurate advantage with respect to corrosion is usually realized.

In the agricultural formulations of this invention, one can employ anionic,

cationic or non-ionic surface-active agents. The surfactants which are useful in the compositions of this invention include those of the cationic, anionic, and non-ionic variety and also amine oxide, imidazolines, propoxylated ethoxylated ethylenediamine, quaternary ammonium compounds, betaine derivatives as well as amphoteric surfactants. Examples of the amine oxides are lauryldimethylamine oxide, cetyldimethylamine oxide, myristyldimethylamine oxide, bis(2-hydroxyethyl)cocoamine oxide and the like. Examples of quaternary amine surfactants are cocotrimethylammonium chloride, alkylamidoethyl alkyl imidazolium methyl methosulfate. Examples of cationic surfactants are N,N-bis(2-hydroxyethyl)alkylamines where the alkyl groups are C_{14} — C_{18} derived from tallow, N,N-bis(α -ethyl-omega-hydroxy)-poly(oxyethylene)alkylamines having an average of 3 oxyethylene groups, the alkyl being C_{14} — C_{18} derived from tallow and (3-lauramidopropyl) trimethylammonium methyl sulfate. Some anionic surface-active agents are the sulfated fatty alcohols and the alkylarylsulfonates. Representative of the sulfated fatty alcohols are the sodium or lower alkanol amine salts of the monoesters of sulfuric acid with N-aliphatic alcohols containing from 8 to 18 carbon atoms. The alkylarylsulfonates are inclusive of the products derived from the alkylation of an aromatic hydrocarbon, e.g., benzene, naphthalene, diphenyl, diphenyl methane and phenoxybenzene, sulfonation of the resulting alkylated aromatic hydrocarbon and neutralization of the sulfonation product with NaOH or KOH, or with a primary or secondary amine.

Some non-ionic surface-active agents are the ethoxylated monoamines having the structure



wherein R is alkyl containing from about 8 to 16 carbon atoms and m is an integer from 2 to 25. Preferred anionic surface-active agents are the aliphatic amine salts of monoalkyl (C_8 — C_{16}) phenoxybenzene disulfonic acids.

All of the alkane thiols and dithiols containing from 2 to 16 carbon atoms in the alkane moiety which have been examined for corrosion inhibition were found effective in substantially eliminating hydrogen evolution under the test conditions herein described. The alkane thiols particularly those containing 8 or less carbon atoms in the alkane moiety have a pronounced disagreeable odor. It is, therefore, preferable to employ alkane thiols having greater than 8 carbon atoms in the alkane moiety. The higher alkane thiols are less odorous and, hence, are preferred in the interests of minimizing worker and user discomfort. The terms "alkane thiol" and "alkane dithiol" are intended to include the normal, secondary and tertiary isomers of these compounds. Representative thiols and dithiols useful in the practice of this invention include 1,2-ethanedithiol, ethanedithiol, 1,3-propanedithiol, 1-propanethiol, 2-propanethiol, 2-methyl-2-propanethiol, 1,4-butanedithiol, 1-butanethiol, 3-methyl-1-butanethiol, 1-hexanethiol, 2-hexanethiol, 3-hexanethiol, 1-octanethiol, 2-octanethiol, 1-decanethiol, 1-dodecanethiol and 1-hexadecanethiol. Representative of the alkali metal salts of the alkane thiols and dithiols are the sodium and potassium salts of 1-ethanethiol, 1-butanethiol, 1-hexanethiol and 1-dodecanethiol. Representative of the ammonium and alkali metal thio salts of inorganic polybasic acids are ammonium thiosulfate, ammonium thiophosphate, ammonium thiocarbonate, sodium thiophosphate, potassium thiophosphate, sodium dimethyldithiocarbonate and sodium thiocarbonate, which unlike the alkane thiols do not contain in their structure an —SH group but nevertheless do inhibit hydrogen evolution to a major extent from steel and zinc surfaces. One can also add compounds such as sodium sulfite to the thiosulfate-containing compositions. Although no improvement in the corrosion inhibition is obtained, this prevents dissociation of the ammonium thiosulfate in this composition.

The corrosion inhibited agricultural compositions of this invention, including concentrates requiring dilution with water prior to plant application, contain from 5 to 95 parts by weight of an agriculturally active agent, from 5 to 95 parts by weight of an adjuvant comprising from 0.25 to 25 parts by weight of a non-ionic or anionic surface-active agent, from 0 to 25 parts by weight of a dispersant and from about 4.5 to about 95 parts by weight of inert liquid extender, e.g., water and from 0.15 to

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2 parts, by weight of a suitable thio compound. The compositions are prepared by mixing the active ingredient, the thio compound, the surface-active agent and the liquid extender to provide liquid compositions in the form of solutions, suspensions, dispersions or emulsions. These liquid compositions immediately prior to application to plants are diluted with water as required to obtain the desired effects (herbicidal or plant growth regulation).

For determining hydrogen evolution, concentrated liquid formulations were prepared according to the following formula, all parts being by weight:

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Monoisopropylamine salt of N-phosphonomethylglycine	41 parts
Surfactant	15 parts
Inhibitor	1 part
Water	43 parts

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The liquid concentrates were then diluted with water to actual spray use concentrations, i.e., 5 parts concentrate to 95 parts water and the diluted formulations were tested for hydrogen evolution and corrosion characteristics. The diluted concentrates are normally more corrosive to metals than the concentrates.

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Hydrogen evolution was measured according to the following procedure. A metal coupon (mild steel or zinc) was horizontally supported within the mouth of an inverted plastic funnel, the support being toothpicks fastened to the rim of the funnel. The dimensions of the steel coupon were 3.2 cm x 1.4 cm x 0.6 cm; the zinc coupons were 3.2 cm x 1.4 cm x 0.2 cm. The funnel assembly with the supported metal coupon was placed into a 250 ml beaker, and enough dilute liquid agricultural formulation was poured into the beaker to completely submerge the funnel. A 100 ml conical graduated glass centrifuge test tube was filled with the formulation, the end of the tube was then finger sealed, inverted and placed over the neck of the funnel. Hydrogen gas evolving from attack on the metal coupon by the formulation ascends upwardly within the conical section of the funnel, then into the funnel neck and finally into the test tube where it collects and displaces the liquid formulation. The amount of collected gas is read directly off the graduations on the test tube. The beaker and its contents are maintained at room temperature during the 24-hour test period.

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The corrosion rate of the coupons was determined by immersing degreased mild steel and zinc coupons in a given formulation at room temperature for 96 hours and then measuring weight loss or gain of the coupon and extrapolating the result to an annual rate of corrosion.

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Water-diluted concentrates prepared as described supra and containing the monoisopropylamine salt of N-phosphonomethylglycine as the active agricultural ingredient were modified by the inclusion of various thiol compounds and surfactants as stated in subsequent Table I. Test data reported in Table I was obtained at room temperature.

TABLE I

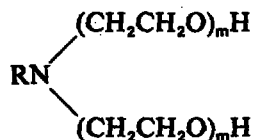
Experiment #	Surfactant*	Weight % Inhibitor in "Concentrate"	Inhibitor	Solution pH	H ₂ Evolution cc During Initial 24 Hours per sq/ft Metal Surface (929 sq/cm)		Corrosion Rate (mm/year)	
					Steel	Zinc	Steel	Zinc
1	A	no inhibitor	1-dodecanethiol	4.5	15.0	2.3	0.080	0.037
2	B	no inhibitor	1-dodecanethiol	4.3	12.4	2.3	0.091	0.049
3	C	no inhibitor	1-dodecanethiol	4.3	18.0	1.4	0.218	0.068
4	A	+1%	1-dodecanethiol	4.5	0	0	0.011	0.026
5	B	+1%	1-dodecanethiol	4.3	0	0	0.013	0.006
6	C	+1%	1-hexadecylthiol	4.3	0	0	0.017	0.008
7	C	+1%	1-octanethiol	4.3	0	0	0.011	0.025
8	C	+1%	1,12-dodecanedithiol		0	0	0.017	0.030
9	C	+1%	sodium salt of dodecanethiol		0	0	0.006	0.013
10	C	+1%	dodecanethiol & oxalic acid equal to weight of isopropylamine salt of N-phosphonomethylglycine		0	0	0.010	0.027
11	C	+1%	dodecanethiol & oxalic acid equal to weight of isopropylamine salt of N-phosphonomethylglycine		0	0	0.020	0.045
12	C	+1%	dodecanesulfide		0.6	0	0.035	0.040
13	C	+1%	dodecanedisulfide		1.9	0	0.033	0.053
14	C	+1%	octanesulfide		1.1	0	0.022	0.045
15	C	+1%	octanedisulfide		0.1	0	0.035	0.093
16	A	+2%	ammonium thiosulfate		0	0	0.040	0.033
17	B	+2%	ammonium thiosulfate		0.3	0.3	0.111	0.119
18	C	+2%	ammonium thiosulfate		0.3	0.3	0.155	0.058

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Experiment #	Surfactant*	Weight % Inhibitor in "Concentrate"	Inhibitor	Solution pH	H ₂ Evolution cc During Initial 24 Hours per sq/ft Metal Surface (929 sq/cm)		Corrosion Rate (mm/year)	
					Steel	Zinc	Steel	Zinc
19	C	+1%	uranomethylthiol		0	3.6	0.058	0.10**
20	C	+1%	alpha mercaptotoluene		0	4.1	0.043	0.075**
21	C	+1%	p-thiocresol		0	0	0.033	0.048
22	C	+1%	1-methyl-1-propanethiol		0	0.6	0.040	0.033
23	C	+1%	2-methyl-1-propanethiol		0	9.8	0.038	0.040
24	A	+1%	sodium thiophosphate		0	6.6	0.022	0.205
25	B	+1%	sodium thiophosphate		0.7	5.1	0.071	0.231
26	C	+1%	sodium thiophosphate		3.4	5.8	0.081	0.152
27	A	+1%	dimethyldithiocarbamic acid sodium salt		0	1.8	0.020	0.099
28	B	+1%	dimethyldithiocarbamic acid sodium salt		0	5.1	0.022	0.104
29	C	+1%	dimethyldithiocarbamic acid sodium salt		0	3.4	0.043	0.093
30	A	+1%	sodium thiocarbonate		0	0.5	0.022	0.086
31	B	+1%	sodium thiocarbonate		0.7	2.9	0.055	0.071
32	C	+1%	sodium thiocarbonate		0.7	1.1	0.068	0.096
33	Distilled water (no inhibitor)				0.4	0.3	0.043	0.022

*Surfactant "A" is a non-ionic type surfactant comprising an ethoxylated tallow amine having the structure



wherein m has an average value of between 15 and 20 and R is alkyl having an average number of carbon atoms of about 17—18.

Surfactant "B" is an anionic type surfactant comprising a mixture which averages about 80 percent or more by weight of a monoisopropylamine salt of a C₁₀ alkyl phenoxybenzene disulfonic acid and up to about 20 percent by weight of dialkylated products of phenoxybenzene disulfonic acid.

Surfactant "C" is also an anionic surfactant and is the triethanolamine salt of a (C₈₋₁₀) alcohol sulfate; (C₈₋₁₀) OSO₂ON(CH₂CH₂OH)₃.

**Weight gain.

Inspection of the data presented in Table I shows that all the tested alkane thiols and dithiols (Experiments 4—9) and the alkali metal salt of an alkane thiol (Experiment 10) were 100 percent effective in preventing evolution of hydrogen on test coupons of steel and zinc. Additionally, they exhibited the lowest corrosion rates of steel and zinc of all the tested inhibitors being less corrosive than even distilled water per se (Experiment 33).

Almost as effective as the thiol and dithiols and alkali metal salts of the thiols in reducing H₂ evolution was ammonium thiosulfate (Experiments 16, 17 and 18), sodium thiophosphate (Experiments 24, 25 and 26), sodium thiocarbonate (Experiments 30, 31 and 32) and sodium dimethyldithiocarbamate (Experiments 27, 28 and 29). Inhibition of corrosion, however, was only fair. The inhibition of H₂ evolution is adequate for safe storage of the ammonium thiosulfate, the sodium thiophosphate and the sodium thiocarbonate inhibited formulations in metal cans, tanks and other metal equipment.

Experiment 11 involved a herbicidal formulation containing in addition to the dodecanethiol inhibitor, the copresence of oxalic acid in an amount equal to the weight of the isopropylamine salt of N-phosphonomethylglycine. The use of oxalic acid in herbicidal formulations containing N-phosphonomethylglycine or its derivatives is disclosed in "Research Disclosure" publication number RD15334, published January, 1977 by Industrial Opportunities Ltd., Homewell-Havant-Hampshire PO9 1EF, United Kingdom. According to said publication, when herbicidal formulations containing N-phosphonomethylglycine or its derivatives are diluted for application purposes with hard water, i.e. water containing calcium or magnesium ions in the range of from 100 to 2000 or more parts by weight per million parts by weight of water, the diluted formulations have diminished herbicidal activity as compared to the same formulations diluted with deionized water. The publication teaches the use of oxalic acid in hard water diluted herbicidal formulations to restore the herbicidal activity and recommends the amount of oxalic acid be at least equivalent to 50 percent of the calcium or magnesium ion to as much as 200 percent or more of such ions present in the diluting hard water. The weight ratio of the N-phosphonomethylglycine compound to oxalic acid ranges from 1 to 10 parts by weight of the glycine compound per 1 to 10 parts by weight of oxalic acid. Oxalic acid is known to be corrosive of iron surfaces. As demonstrated by the data in Table I for Experiment 11, the normal corrosive action of oxalic acid on iron surfaces is satisfactorily inhibited when a thiol compound is present in the herbicidal formulation.

That the use of thio compounds as inhibitors of metal corrosion in herbicidal compositions containing an amine salt of N-phosphonomethylglycine does not significantly diminish post-emergent herbicidal activity of the composition is quite evident from the data presented in Table II on the post-emergence killing of quackgrass using formulations described in Table I, being Experiments 1 to 6 and 16 to 18. The experimental formulations were suitably diluted with water and applied to quackgrass plants established from vegetative propagules at a rate of 187 liters per hectare. Plants treated with the experimental formulations were placed in

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a greenhouse and observed and recorded 12 days after treatment with the herbicidal formulation.

TABLE II

Experiment Number	Surfactant	Inhibitor	Rate (kg/h)*	% Inhibition Plant Response (% Quackgrass 12 Days After Treatment)
1	A	None	1.12	95
2	B	None	0.56	95
3	C	None	0.28	40
4	A	Dodecanethiol	1.12	99
5	B	Dodecanethiol	0.56	99
6	C	Dodecanethiol	0.28	50
16	A	Ammonium thiosulfate	1.12	99
17	B	Ammonium thiosulfate	0.56	99
18	C	Ammonium thiosulfate	0.28	60

*Amount of monoisopropylamine salt of N-phosphonomethylglycine applied per hectare.

In order to determine what effect on post-emergence herbicidal activity would result when the quantity of thiol inhibitor in a herbicidal formulation containing the monoisopropylamine salt of N-phosphonomethylglycine as the active ingredient was increased many fold beyond that required for adequate inhibition of hydrogen evolution and metal corrosion, two control formulations were prepared, one containing previously described surfactant "A" and the other surfactant "C" according to the following formula, all parts being by weight:

Monoisopropylamine salt of N-phosphonomethylglycine	41 parts
Surfactant	15 parts
Water	44 parts

The formulations were then diluted with water and sufficient additional surfactant added to the diluted formulations for the surfactant to constitute in each instance 1 percent by weight of the diluted formulation. The amount of water used to prepare the diluted formulations was so adjusted that each diluted formulation could be spray applied to the plants at a common rate of 187 liters per hectare, even though the amount of active ingredient in each diluted formulation was maintained at different levels. The amount of thiol inhibitor in each diluted formulation was also adjusted to maintain a constant application of 4.48 kilograms per hectare when the diluted formulation was spray applied at 187 liters per hectare. The diluted formulations (with and without inhibitor) were sprayed on 3 week old greenhouse grown Johnson grass and quackgrass and the observations as to herbicidal effectiveness reported in Table III were made 28 days later.

TABLE III

	Surfactant	Formulation Inhibitor	Rate (kg/h)*	% Inhibition		
				Johnson Grass	Quackgrass	
5	A	None	0.28	100	100	5
	A	None	0.14	65	98	
	A	None	0.07	35	25	
	A	None	0.035	0	20	
	C	None	0.28	95	100	
10	C	None	0.14	60	95	10
	C	None	0.07	30	35	
	C	None	0.035	0	20	
	A	Octanethiol	0.28	85	100	
	A	Octanethiol	0.14	55	65	
15	A	Octanethiol	0.07	30	15	15
	A	Octanethiol	0.035	0	0	
	C	Octanethiol	0.28	85	75	
	C	Octanethiol	0.14	35	45	
	C	Octanethiol	0.07	20	30	
20	C	Octanethiol	0.035	0	0	20
	A	1,12-Dodecanedithiol	0.28	90	100	
	A	1,12-dodecanedithiol	0.14	60	90	
	A	1,12-dodecanedithiol	0.07	15	25	
	A	1,12-dodecanedithiol	0.035	0	15	
25	C	1,12-dodecanedithiol	0.28	85	100	25
	C	1,12-dodecanedithiol	0.14	35	70	
	C	1,12-dodecanedithiol	0.07	20	40	
	C	1,12-dodecanedithiol	0.035	0	20	

*Amount of monoisopropylamine salt of N-phosphonomethylglycine applied per hectare.

Although the amount of thiol inhibitor to active ingredient of the formulations described in Table III ranged from 164:1 at the 0.28 kg/h rate to a high of 1312:1 at the 0.035 kg/h rate of active ingredient, only a slight diminution of herbicidal effectiveness was observed and this occurred principally at ratios of thiol inhibitor to active ingredient or more than 164:1.

Although the inhibitor efficacy of various thio compounds was exemplified with the monoisopropylamine salt of N-phosphonomethylglycine in Table I, substantially similar corrosion inhibition can be expected when a thio compound as herein disclosed is admixed with other salts and esters of N-phosphonomethylglycine such as the alkali metal salts as are disclosed in U.S. Patent No. 3,977,860. Such salts and esters include but are not limited to the following:

monocyclohexylamine salt of N-phosphonomethylglycine
 di(methylamine) salt of N-phosphonomethylglycine
 di(dimethylamine) salt of N-phosphonomethylglycine
 di(ethylamine) salt of N-phosphonomethylglycine
 di(n-propylamine) salt of N-phosphonomethylglycine
 di(morpholine) salt of N-phosphonomethylglycine
 mono(stearylamine) salt of N-phosphonomethylglycine
 mono(tallowamine) salt of N-phosphonomethylglycine
 mono(methylbutyl) salt of N-phosphonomethylglycine
 mono(butylamine) salt of N-phosphonomethylglycine
 n-dibutylamine salt of N-phosphonomethylglycine
 n-octadecylamine salt of N-phosphonomethylglycine
 methoxyethylamine salt of N-phosphonomethylglycine
 ethylenediamine salt of N-phosphonomethylglycine
 dipropanolamine salt of N-phosphonomethylglycine
 chloroethylamine salt of N-phosphonomethylglycine
 phenoxyethylamine salt of N-phosphonomethylglycine
 mono(triethylamine) salt of N-phosphonomethylglycine
 mono(diethylenetriamine) salt of N-phosphonomethylglycine

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	monoisopropylamine salt of N-phosphonomethylglycine	
	monomorpholine salt of N-phosphonomethylglycine	
	monoaniline salt of N-phosphonomethylglycine	
5	monoethanolamine salt of N-phosphonomethylglycine	5
	monodiethanolamine salt of N-phosphonomethylglycine	
	monoammonium salt of N-phosphonomethylglycine	
	monosodium salt of N-phosphonomethylglycine	
	disodium salt of N-phosphonomethylglycine	
10	trisodium salt of N-phosphonomethylglycine	10
	monopotassium salt of N-phosphonomethylglycine	
	dipotassium salt of N-phosphonomethylglycine	
	tripotassium salt of N-phosphonomethylglycine	
	dilithium salt of N-phosphonomethylglycine	
15	monosodium salt of ethyl N-phosphonomethylglycinate	15
	monosodium salt of chloroethyl N-phosphonomethylglycinate	
	methyl N-phosphonomethylglycinate	
	dimethyl N-phosphonomethylglycinate	
	ethyl N-phosphonomethylglycinate	
20	2-chloroethyl N-phosphonomethylglycinate	20
	n-propyl N-phosphonomethylglycinate	
	n-butyl N-phosphonomethylglycinate	
	n-hexyl N-phosphonomethylglycinate	
	cyclohexyl N-phosphonomethylglycinate	
25	n-octyl N-phosphonomethylglycinate	25
	n-decyl N-phosphonomethylglycinate	
	n-dodecyl N-phosphonomethylglycinate	

Representative but not inclusive of the aminophosphonates described in U.S. Patent No. 3,556,762 and which in aqueous formulations cause corrosion of metal surfaces are the following compounds:

30	nitrilodi (acetic acid) (methylphosphonic acid)	30
	tris(dimethylammonium)iminoacetate N-methylphosphonate	
	trisodium iminodiacetate N-methylphosphonate	
	tetra(dimethylammonium)aminoacetate N,N-bis-methylphosphonate	
35	2,2'-bisphosphonomethyliminoacetic acid	35
	dipotassium iminodiacetate N-methyl-O-potassium-O-ethylphosphonate	

Data on hydrogen evolution and corrosion inhibition by dodecanethiol for several agricultural formulations containing as an active ingredient N-phosphonomethylglycine or salt or ester derivative thereof or an aminophosphonate compound are tabulated in Table IV. The formulations used in Table IV were of two types, liquid and dry powder. Experiments 34 and 35 were conducted on liquid formulations of the following compositions, all parts being by weight:

	Experiment 34	
45	Di-(moniosopropylamine) salt of N-phosphonomethylglycine	45
	Surfactant "C"	41
	Water	15
		44
	Experiment 35	
50	Di-(monoisopropylamine) salt of N-phosphonomethylglycine	50
	Surfactant "C"	41
	Dodecanethiol	15
	Water	1
		43

The dry powder formulations, Experiments 36 to 47 had the following compositions, all parts being by weight:

55	Experiment 36	
	Disodium salt of N-phosphonomethylglycine	78
	Surfactant "D"	2
	Urea	20

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Experiment 37		
	Disodium salt of N-phosphonomethylglycine	78
	Surfactant "D"	2
	Dodecanethiol —	9.2
5	Urea Complex (2.1 parts thiol) (7.1 parts urea)	5
	Urea	10.9
Experiment 38		
10	Diammonium salt of N-phosphonomethylglycine	74.6
	Surfactant "D"	2
	Urea	23.4
Experiment 39		
	Diammonium salt of N-phosphonomethylglycine	74.6
	Surfactant "D"	2
15	Dodecanethiol —	9.2
	Urea Complex (2.1 parts thiol)	
	Urea Complex (7.1 parts urea)	
	Urea	14.3
Experiment 40		
20	Dipotassium salt of N-phosphonomethylglycine	89.7
	Surfactant "D"	2
	Urea	8.3
Experiment 41		
	Dipotassium salt of N-phosphonomethylglycine	87.7
25	Surfactant "D"	2
	Dodecanethiol —	9.2
	Urea complex (2.1 parts thiol) (7.1 parts urea)	
	Urea	1.2
Experiment 42		
30	N-phosphonomethylglycine	64.4
	Surfactant "D"	2
	Urea	33.6
Experiment 43		
35	N-phosphonomethylglycine	64.4
	Surfactant "D"	2
	Dodecanethiol —	9.2
	Urea Complex (2.1 parts thiol) (7.1 parts urea)	
40	Urea	22.4
Experiment 44		
	2,2'-bisphosphonomethyliminoacetic acid	51
	Surfactant "D"	2
	Urea	47
Experiment 45		
45	2,2'-bisphosphonomethyliminoacetic acid	52
	Surfactant "D"	2
	Dodecanethiol —	9.2
	Urea Complex (2.1 parts thiol) (7.1 parts urea)	
50	Urea	37.9
Experiment 46		
	Monoethyl ester of N-phosphonomethylglycine	86.3
	Surfactant "D"	2
55	Urea	11.7

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Experiment 47

Monoethyl ester of N-phosphonomethylglycine
Dodecanethiol —

86.3

9.2

Urea Complex (2.1 parts thiol)
(7.1 parts urea)

5

Urea

2.5

5

Surfactant "C" is as previously described.

Surfactant "D", an anionic surfactant, is a complex of sodium dioctyl-sulfosuccinate.

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Experiments 34, 36, 38, 40, 42 and 44 were control experiments containing no inhibitor. Experiments 37, 39, 41, 43 and 45 were dry solid formulations containing a complex of urea and dodecanethiol. Alkane thiols such as dodecanethiol are substantially water insoluble and although a surfactant is an aid in effecting dispersion of the thiol in an aqueous formulation, it has been found that a solid complex of urea and a straight chain alkane thiol when mixed with a dry mixture of the active ingredient and surfactant enhances dispersibility of the thiol in aqueous agricultural formulations and minimizes separation of the thiol component. The complex dissolves readily in water to reform the urea and the thiol with the thiol being finely dispersed and remaining in suspension. The urea-thiol complex is prepared by dissolving the alkane thiol in a solvent such as isooctane and mixing the solution at room temperature with sufficient urea prewetted with methanol until the urea increases in volume; the reaction is slightly exothermic. The molar ratio of urea to alkane thiol used to form the complex is proportional to the thiol's chain length being at least 6:1 for alkane thiols containing 6 carbon atoms, 10:1 moles for dodecanethiol and about 16:1 for thiols of 16 carbon atoms. The solvents used in the reaction are removed by washing and drying. The corrosion experiments reported in Table IV were all conducted with the liquid as well as the solid type formulations having been diluted with water in amount corresponding to normal application dilutions, namely a dilution that would apply per hectare 2.24 kilograms of active ingredient (calculated as N-phosphonomethylglycine or 2,2'-bisphosphonomethyliminoacetic acid) at a spraying rate of 187 liters per hectare.

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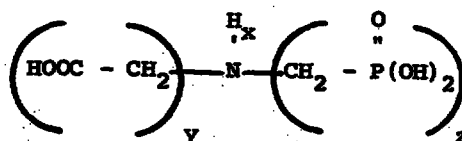
TABLE IV

Ex. No.	Surfactant	Active Ingredient	Inhibitor	pH	H ₂ Evolution cc/sq. ft.		Corrosion Rate (mm/hr)	
					from Steel 0-24 Hours	from Zinc 0-24 Hours	Steel	Zinc
34	C	Diisopropylamine salt of N-phosphonomethylglycine	None	7.17	5.3	1.8	0.266	0.320
35	C	Diisopropylamine salt of N-phosphonomethylglycine	Dodecanethiol	7.10	0	0	0.012	0.005
36	D	Disodium salt of N-phosphonomethylglycine	None	6.54	4.99	0	0.172	0.055
37	D	Disodium salt of N-phosphonomethylglycine	Dodecanethiol	6.79	0	0	0.017	0.017
38	D	Diammonium salt of N-phosphonomethylglycine	None	6.56	5.20	0.60	0.132	0.045
39	D	Diammonium salt of N-phosphonomethylglycine	Dodecanethiol	6.60	0	0	0.010	0.010
40	D	Dipotassium salt of N-phosphonomethylglycine	None	6.70	6.19	0.8	0.0812	0.035
41	D	Dipotassium salt of N-phosphonomethylglycine	Dodecanethiol	6.79	0	0	0.007	0.002
42	D	N-phosphonomethylglycine	None	2.17	4.3	89.9	0.010	2.029
43	D	N-phosphonomethylglycine	Dodecanethiol	2.14	0	0.8	0.003	0.187
44	D	2,2'-bis-phosphonomethyl-iminoacetic acid	None	—	233	720	6.45	23.3
45	D	2,2'-bis-phosphonomethyl-iminoacetic acid	Dodecanethiol	—	0	2.9	0.030	0.038
46	D	Monoethyl ester of N-phosphonomethylglycine	None	—	0.6	0.5	0.040	0.063
47	D	Monoethyl ester of N-phosphonomethylglycine	Dodecanethiol	—	0	0	0.020	0.030

Thiols other than the alkane thiols have also been found effective in inhibiting corrosion by aqueous agricultural compositions as herein contemplated. Such thiols include the aromatic and cycloaliphatic thiols. For example, 2% inhibiting amounts of p-chlorothiophenol, 2-aminothiophenol, 2-furanomethanethiol, toluenethiol, 2-benzoxazolthiol and mercaptobenzothiazole enable a dry disodium salt of N-phosphonomethylglycine formulation corresponding to Experiment 36 when diluted with water reduces the hydrogen evolution and the metal corrosion rate. Similar corrosion inhibition was obtained when fertilizer diluent ingredients other than urea were included in the agricultural formulations, as, for example, monoammonium phosphate and disodium phosphate.

WHAT WE CLAIM IS:—

1. An agricultural composition comprising as an agricultural active ingredient from 5 to 95 parts by weight of an aminomethylenephosphonic acid of the formula



wherein y and z are each individually 1 or 2, and x is 0 or 1, the sum of x, y and z being 3, or an agriculturally acceptable salt or ester thereof, from 5 to 95 parts by weight of an adjuvant comprising from 0.25 to 25 parts by weight of a non-ionic or anionic surface active agent, from 0 to 25 parts of a dispersant, and from 4.5 to 95 parts by weight of an inert liquid extender, and from 0.15 to 3% by weight of said aminomethylenephosphonic acid of a thio compound selected from the alkane thiols and dithiols having from 2 to 16 carbon atoms in the alkane moiety, aromatic thiols, cycloaliphatic thiols, the alkali metal salt of said thiols and dithiols and the ammonium and alkali metal thio salts of polybasic inorganic acids for all combinations of x, y and z excepting the combination x=y=z=1 representative of N-phosphonomethylglycine wherein said thio compound comprises from 0.15 to 20% by weight of the said N-phosphonomethylglycine.

2. An agricultural composition according to Claim 1 wherein the alkane thiol is 1-dodecanethiol.

3. An agricultural composition according to Claim 1 wherein the alkane thiol is 1-octanethiol.

4. An agricultural composition according to Claim 1 wherein the alkane thiol is 1-hexadecylthiol.

5. An agricultural composition according to Claim 1 wherein the ammonium thio salt is ammonium thiosulfate.

6. An agricultural composition according to Claim 1 wherein the ammonium thio salt is ammonium thiophosphate.

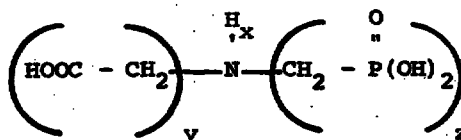
7. An agricultural composition according to Claim 1 containing between 1 and 10 parts by weight of oxalic acid per 1 to 10 parts by weight of an amine salt of N-phosphonomethylglycine.

8. A dry agricultural composition according to Claim 1 wherein the thiol is a straight chain alkane thiol and complexed with urea, the molar ratio of the thiol to urea being proportional to the carbon atom chain in the alkane thiol being at least 1:6 for a six carbon thiol and at least 1:16 for a sixteen carbon thiol.

9. An agricultural composition according to Claim 1 wherein the active ingredient is 2,2'-bisphosphomethyliminoacetic acid.

10. An agricultural composition according to Claim 1 wherein the active ingredient is the monoisopropylamine salt of N-phosphonomethylglycine.

11. A method for inhibiting corrosion of iron and zinc metal surfaces in contact with an aqueous agricultural composition comprising from 5 to 95 parts by weight water, from 0 to 25 parts by weight of a surfactant and an active ingredient selected from the aminomethylenephosphonic acids of the formula

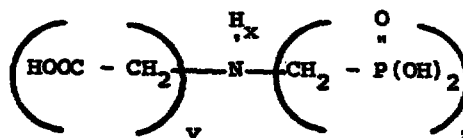




Thiols other than the alkane thiols have also been found effective in inhibiting corrosion by aqueous agricultural compositions as herein contemplated. Such thiols include the aromatic and cycloaliphatic thiols. For example, 2% inhibiting amounts of p-chlorothiophenol, 2-aminothiophenol, 2-furanomethanethiol, toluenethiol, 2-benzoxazolthiol and mercaptobenzothiazole enable a dry disodium salt of N-phosphonomethylglycine formulation corresponding to Experiment 36 when diluted with water reduces the hydrogen evolution and the metal corrosion rate. Similar corrosion inhibition was obtained when fertilizer diluent ingredients other than urea were included in the agricultural formulations, as, for example, monoammonium phosphate and disodium phosphate.

WHAT WE CLAIM IS:—

1. An agricultural composition comprising as an agricultural active ingredient from 5 to 95 parts by weight of an aminomethylenephosphonic acid of the formula



wherein y and z are each individually 1 or 2, and x is 0 or 1, the sum of x, y and z being 3, or an agriculturally acceptable salt or ester thereof, from 5 to 95 parts by weight of an adjuvant comprising from 0.25 to 25 parts by weight of a non-ionic or anionic surface active agent, from 0 to 25 parts of a dispersant, and from 4.5 to 95 parts by weight of an inert liquid extender, and from 0.15 to 3% by weight of said aminomethylenephosphonic acid of a thio compound selected from the alkane thiols and dithiols having from 2 to 16 carbon atoms in the alkane moiety, aromatic thiols, cycloaliphatic thiols, the alkali metal salt of said thiols and dithiols and the ammonium and alkali metal thio salts of polybasic inorganic acids for all combinations of x, y and z excepting the combination $x=y=z=1$ representative of N-phosphonomethylglycine wherein said thio compound comprises from 0.15 to 20% by weight of the said N-phosphonomethylglycine.

2. An agricultural composition according to Claim 1 wherein the alkane thiol is 1-dodecanethiol.

3. An agricultural composition according to Claim 1 wherein the alkane thiol is 1-octanethiol.

4. An agricultural composition according to Claim 1 wherein the alkane thiol is 1-hexadecylthiol.

5. An agricultural composition according to Claim 1 wherein the ammonium thio salt is ammonium thiosulfate.

6. An agricultural composition according to Claim 1 wherein the ammonium thio salt is ammonium thiophosphate.

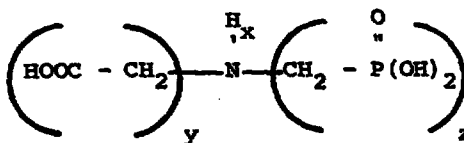
7. An agricultural composition according to Claim 1 containing between 1 and 10 parts by weight of oxalic acid per 1 to 10 parts by weight of an amine salt of N-phosphonomethylglycine.

8. A dry agricultural composition according to Claim 1 wherein the thiol is a straight chain alkane thiol and complexed with urea, the molar ratio of the thiol to urea being proportional to the carbon atom chain in the alkane thiol being at least 1:6 for a six carbon thiol and at least 1:16 for a sixteen carbon thiol.

9. An agricultural composition according to Claim 1 wherein the active ingredient is 2,2'-bisphosphomethyliminoacetic acid.

10. An agricultural composition according to Claim 1 wherein the active ingredient is the monoisopropylamine salt of N-phosphonomethylglycine.

11. A method for inhibiting corrosion of iron and zinc metal surfaces in contact with an aqueous agricultural composition comprising from 5 to 95 parts by weight water, from 0 to 25 parts by weight of a surfactant and an active ingredient selected from the aminomethylenephosphonic acids of the formula





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5 wherein y and z are each individually 1 or 2, and x is 0 or 1, the sum of x, y and z being 3, and the agriculturally acceptable salts and esters thereof which comprises adding to the composition from 0.15 to 3% by weight of said aminomethylenephosphonic acid of a thio compound selected from alkane thiols and dithiols having from 2 to 16 carbon atoms in the alkane moiety, aromatic thiols, cycloaliphatic thiols, the alkali metal salts of said thiols and dithiols and the ammonium and alkali metal thio salts of polybasic inorganic acids for all combinations of x, y and z excepting the combination x=y=z=1 representative of N-phosphonomethylglycine wherein said thio compound comprises from 0, 15 to 20% by weight of the said N-phosphonomethylglycine. 10

12. A method in accordance with Claim 11 wherein the alkane thiol is a 1-dodecanethiol.

13. A method in accordance with Claim 11 wherein the alkane thiol is 1-octanethiol.

14. A method in accordance with Claim 11 wherein the alkane thiol is 1-hexadecylthiol.

15. A method in accordance with Claim 11 wherein the thio compound is ammonium thiosulfate.

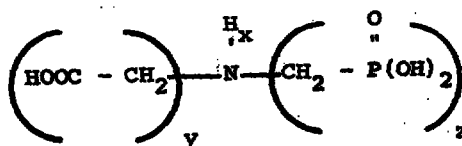
16. A method in accordance with Claim 11 wherein the thiol is an alkane thiol complexed with urea and the urea-thiol complex is admixed with a dry mixture of the active ingredient and the surfactant before dispersing in water. 20

17. A method which comprises contacting a plant with a phytotoxic amount of an aqueous herbicidal composition comprising from 5 to 95 parts by weight an amine salt of N-phosphonomethylglycine, from 0 to 25 parts by weight of a surfactant, from 5 to 95 parts by weight water and from 0.15 to 3% by weight of said aminomethylenephosphonic acid of a thio compound selected from alkane thiols and dithiols having from 2 to 16 carbon atoms in the alkane moiety, aromatic thiols, cycloaliphatic thiols, the alkali metal salts of said thiols and dithiols and the ammonium and alkali metal thio salts of polybasic inorganic acids for all combinations of x, y and z excepting the combination x=y=z=1 representative of N-phosphonomethylglycine wherein said thio compound comprises from 0.15 to 20% by weight of the said N-phosphonomethylglycine. 25

18. A method according to Claim 17 wherein the thio compound constitutes between 0.15 and 3 percent by weight of the amine salt of N-phosphonomethylglycine. 30

19. A method according to Claim 17 wherein the amine salt is the monoisopropylamine salt of N-phosphonomethylglycine. 35

20. A method which comprises contacting a plant with a plant growth regulating amount of an aqueous plant growth regulating composition comprising from 5 to 95 parts by weight of an aminomethylenephosphonic acids having the formula 40



45 wherein y and z are each individually 1 or 2, and x is 0 or 1, the sum of x, y and z being 3, and the agriculturally acceptable salts and esters thereof, from 5 to 95 parts by weight of an adjuvant comprising from 0.25 to 25 parts by weight of a non-ionic or anionic surface active agent, from 0 to 25 parts of a dispersant, and from 4.5 to 95 parts by weight of an inert liquid extender, and from 0.15 to 3% by weight of said aminomethylenephosphonic acid of a thio compound selected from the alkane thiols and dithiols having from 2 to 16 carbon atoms in the alkane moiety, aromatic 45



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5 thiols, cycloaliphatic thiols, the alkali metal salts of said thiols and dithiols and the ammonium and alkali metal thio salts of polybasic inorganic acids for all combinations of x, y and z excepting the combination $x=y=z=1$ representative of N-phosphonomethylglycine wherein said thio compound comprises from 0, 15 to 20% by weight of the said N-phosphonomethylglycine.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1981
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from
which copies may be obtained.