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ARSENIC-BORON COMPOUNDS AND METHOD OF INHIBITING CORROSION THEREWITH

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This invention relates to new arsenical compositions and to a method of employing the compositions to inhibit corrosion. More specifically, the invention pertains to new compounds of the elements arsenic and boron and to the use of those compounds in inhibiting corrosion of ferrous metals by aqueous acid solutions, particularly in oil wells.

The best known and most widely used commercial arsenic compound, arsenous oxide or arsenic trioxide (As_2O_3), is characterized by several properties which make it difficult to handle and generally unsatisfactory for a variety of uses. In the first place, arsenous oxide is extremely dusty and powdery, which means that during any handling or pouring operations great precautons must be taken to prevent the operators from breathing the powder because of danger of poisoning. In the second place, arsenous oxide is only slightly soluble in water and must be combined with a strong alkali in order to make it soluble in practical concentrations. Because of the necessity for combining arsenous oxide with strong alkali, the resulting commercial product is subject to all of the hazards inherent in strong alkalies generally and is otherwise dangerous in that it may not be exposed to an active metal, such as zinc, since deadly arsine gas may then be generated. The danger involved when zinc is exposed to arsenous oxide in alkali solutions prevents the use of economical and desirable galvanized handling equipment.

In addition to arsenous oxide, there exist other commercial arsenic compounds one of the most important of which is sodium arsenite ($NaAsO_2$) which is soluble in water but is caustic. It is, therefore, subject to the dangers inherent in strong alkalies and to the dangers involved when placed in contact with active metals such as zinc. Sodium arsenite is also highly dusty and powdery, and the dust is easily assimilated by the human body thus greatly increasing the handling hazards. A further commercial arsenic compound is arsenic chloride ($AsCl_3$), but this compound is so dangerous that its use has been extremely limited.

One important commercial use of arsenous oxide is in the inhibition of corrosion of ferrous metal surfaces exposed to aqeuous acid solutions such as are present in oil wells. To be sufficiently soluble for this use, the arsenous oxide must be mixed with a strong alkali such as sodium hydroxide, a solution of arsenous oxide in aqueous sodium hydroxide (sodium arsenite) being introduced into the well through the annulus between the well casing and tubing. As the solution thus introduced falls through the annulus it encounters the carbon dioxide gas naturally present in the well, and the carbon dioxide gas is absorbed by the water in the inhibitor solution to form carbonic acid. The carbonic acid then neutralizes the sodium hydroxide and results in the precipitation of arsenous oxide, a poisonous paste or scum, on the casing and tubing. This process of precipitation is recognized to occur because sodium arsenite is stable only in highly basic solutions and therefore decomposes to form insoluble arsenous oxide as the base is neutralized by carbonic acid. The described precipitation has two highly detrimental effects, the first of which is that the poisonous precipitate is a hazard to personnel handling the tubing during maintenance work, and the second of which is that the arsenous oxide thus precipitated is ineffective to prevent corrosion and thus is wasted.

In view of the above factors characteristic of commercial arsenic compounds in general, and the use of arsenous oxide in inhibiting corrosion in particular, it is an object of the present invention to provide new arsenical compounds which are easy to handle safely, which are simple and inexpensive to manufacture, and which are highly soluble in water to produce essentially neutral solutions free from the characteristic of precipitating arsenous oxide.

Another object of the invention is to provide new arsenical compounds which in solid form are crystalline in character instead of dusty or powdery, so that no poisonous dust is raised into the air during handling and pouring operations.

A further object of the invention is to provide arsenic compounds which in aqueous solution are essentially neutral instead of strongly alkaline, so that none of the dangers inherent in alkalies are present and no dangerous reactions occur when aqueous solutions of the compounds are used or stored in galvanized containers, or otherwise exposed to active metals.

A further object is to provide novel arsenical compounds which are effective inhibitors of corrosion of ferrous metal surfaces by aqueous acid solutions, and whose solubilities are not reduced by exposure to carbon dioxide or to carbonic acid.

A further object of the invention is to provide a method of inhibiting corrosion of ferrous metal surfaces exposed to aqueous acid solutions, and specifically to a method of inhibiting corrosion of ferrous metal oil well equipment without causing precipitation of arsenous oxide onto the equipment.

The and other objects and advantages of the invention will be more fully set forth in the following specification and claims setting forth the compounds of the invention and the method of inhibiting corrosion.

Stated generally, the new compounds comprise chemical combinations of arsenous oxide and a borate in a molar ratio which will give the equivalent of one arsenic atom to one boron atom in the new compounds. Where tetraborate is employed, the molar ratio between arsenous oxide and tetraborate is two to one, respectively. The borate is a borate of an alkali metal or ammonium. Borates of sodium and ammonium are preferred since these borates are relatively inexpensive and the resulting compounds are highly soluble in water. Potassium borate is also preferred but is of lesser value for certain applications since the resulting compound, although many times more soluble than arsenous oxide, is less soluble than compounds prepared with the borates of sodium and ammonium.

According to a more specific definition, the new compounds may be stated to have the general formula $XYB_4O_7 \cdot 2As_2O_3$, where both X and Y are materials selected from a group consisting of the alkali metals and ammonium. The materials may be similar, for example Na_2, or dissimilar, for example NaK. The symbol XY thus represents one of the following combinations: Na_2, K_2, Li_2, $(NH_4)_2$, NaK, NaLi, $NaNH_4$, KLi, KNH_4, $LiNH_4$. Where the materials are similar, the formula may also be written $X_2B_4O_7 \cdot 2As_2O_3$.

A first preferred compound may be formed by dissolving sodium tetraborate ($Na_2B_4O_7$) and arsenous oxide

(As_2O_3) in water, and in the molar ratio of one to two, the resulting compound having the formula

$$Na_2B_4O_7 \cdot 2As_2O_3$$

The sodium tetraborate (borax) and arsenous oxide go into solution readily upon boiling, and the compound is stable in water solution throughout a wide range of temperatures. If, however, an excess of either borax or arsenous oxide is present over the molar ratio of one to two, and the salts are dissolved in hot water, the excess borax or arsenous oxide will precipitate out after the solution is cooled except for the small amount of excess arsenous oxide or borax which would be itself soluble in cold water.

From the water solution of the compound

$$Na_2B_4O_7 \cdot 2As_2O_3$$

a crystalline precipitate or tri-hydrate having the formula $Na_2B_4O_7 \cdot 2As_2O_3 \cdot 3H_2O$ may be formed by introduction of a suitable water miscible organic solvent such as acetone or dioxane, the precipitate being separated by filtering or draining. Essentially complete precipitation of the compound is assured by the addition of four volumes of organic solvent to one volume of the water solution containing the compound $Na_2B_4O_7 \cdot 2As_2O_3$. When precipitation of the new compound is effected with certain solvents, the resulting solid is one in which all or part of the hydrate water is replaced by molecules of the solvent itself. The solid compound may be formed not only by precipitation, as above stated, but also by evaporation or spray drying. For example, when the water solution of the compound is boiled for a long period of time glasses are formed that become more and more viscous as evaporation progresses, the end products being a hard glass and then the tri-hydrate.

The principal properties of the aqueous solution of the new compound, which may be termed disodium arseno-borate, include its high stability and its large content of solids. With relation to the stability of the compound in aqueous solution, it has been found that no decomposition occurs, although experiments have indicated that the sodium is present in ionizable form so that it may be replaced by other cationic species. The ion equation is believed to be as follows:

$$Na_2B_4O_7 \cdot 2As_2O_3 \rightleftarrows Na^+ + (NaB_4O_7 \cdot 2As_2O_3)^- \rightleftarrows 2Na^+ + (B_4O_7 \cdot 2As_2O_3)^=$$

With relation to the high solid content of the aqueous solution, more than fifty percent of the compound remains in solution at ten degrees centigrade. This is to be compared with the solubilities of the constituent compounds themselves since at ten degrees centigrade only 1.6 percent of $Na_2B_4O_7 \cdot 10H_2O$, and only 1.5 percent of As_2O_3, will remain in solution in water. An important feature of the aqueous solution is its relative neutrality, it having a pH of 7.9. It follows that the aqueous solution of the new compound will not react with active metal such as zinc to produce arsine gas, and that there will be relatively little danger in handling the compound.

The properties or characteristics of the compound in its hydrate or solid form include its crystalline character, similar to table salt, as distinguished from powder which is the form of common commercial arsenic compounds such as arsenous oxide and sodium arsenite. Because it is crystalline instead of powdery in character there is little danger that the solid will pass into the air during handling, where it could be breathed with consequent danger of poisoning. That the solid form of the disodium arseno-borate compound is stable is evidenced by the fact that it has been heated for a period of several hours at 350 degrees centigrade without signs of decomposition. This is to be compared with $Na_2B_4O_7 \cdot 10H_2O$ which melts at 75 degrees centigrade, and with arsenous oxide which sublimes at 315 degrees centigrade.

Proceeding next to the analysis of the disodium arseno-

borate compound, a water solution prepared from sodium tetraborate and arsenous oxide, in a molar ratio of one to two, respectively, was used as the source of the crystalline precipitate $Na_2B_4O_7 \cdot 2As_2O_3 \cdot 3H_2O$, precipitation occurring upon addition of dioxane as above indicated. The precipitate was redissolved in water, re-precipitated and dried in air at 110 degrees centigrade. It was determined that the new precipitate did not contain either sodium borate or arsenous oxide, this being accomplished by tests of the physical properties to show, for example, that the precipitate was easily and highly soluble in cold water and was stable above 350 degrees centigrade. The new precipitate was analyzed for arsenic by the arsenous trisulphide method, in accordance with the procedure described in "Scott's Standards Methods of Chemical Analysis," fifth edition, volume 1, page 96. The boron content was determined by titration according to the method described in Analytical Chemistry 22, 697 (1950). It was found that 30.9 percent boron was present as $Na_2B_4O_7$, and that 61.2 percent arsenic was present as As_2O_3, the combined percentages being 92.1 percent which leaves 7.9 percent for water of crystallization.

Comparison of determined and calculated percentages for $Na_2B_4O_7 \cdot 2As_2O_3 \cdot 3H_2O$ are as follows:

	Experimentally Determined	Calculated From Formula
Percent $Na_2B_4O_7$	30.9	30.9
Percent As_2O_3	61.2	60.8
Percent H_2O (By difference)	7.9	8.3

The compound having the formula

$$Na_2B_4O_7 \cdot 2As_2O_3 \cdot 3H_2O$$

would have a sodium content of 9.42% calculated as Na_2O. Determination of the sodium content by flame spectrometric methods gave 9.37%. From the above it may be seen that the formula of the tri-hydrate

$$Na_2B_4O_7 \cdot 2As_2O_3 \cdot 3H_2O$$

is correct to within normal limits of experimental accuracy.

The following is a specific example of the preparation of the disodium arseno-borate compound which is formed, as stated above, by dissolving borax (sodium tetraborate) and arsenous oxide in water and in the molar ratio of one to two, respectively. 19.8 grams of arsenous oxide and 19.1 grams of $Na_2B_4O_7 \cdot 10H_2O$ were dissolved in 65 grams of water. The solids went into solution upon boiling for several minutes. The solid compound was then formed both by evaporation and by precipitation with a water miscible organic solvent as described heretofore.

As a second method of forming the disodium arseno-borate compound, and which may be termed the indirect method as distinguished from the direct method stated aboxe, arsenous oxide is first dissolved in an equal molar ratio of aqueous sodium hydroxide. Boric acid is then added in a molar ratio to the arsenous oxide of 2 to 1 and solution again achieved. This reaction may be represented by the following equation:

$$2As_2O_3 + 2NaOH + 4H_3BO_3 \rightarrow Na_2B_4O_7 \cdot 2As_2O_3 + 7H_2O$$

As a specific example of the indirect method, 19.8 grams of arsenous oxide and 4 grams of sodium hydroxide were mixed in 100 grams of water, and the mixture boiled until the solids dissolved. 12.4 grams of boric acid were then added and the solution boiled until clear. From this solution, $Na_2B_4O_7 \cdot 2As_2O_3$ was precipitated by both of the above described methods.

The second preferred compound formed by combining tetraborate and arsenous oxide in the molar ratio of one to two contains ammonium, arsenic and boron and has the formula $(NH_4)_2B_4O_7 \cdot 2As_2O_3$, with varying numbers of water molecules. This ammonium compound, which may be termed diammonium arseno-borate, may also be formed both by direct and indirect methods. In the direct method the compound is formed by dissolving arsenous oxide in a water solution of ammonium tetraborate, the molar ratio being two to one. More specifically, a solution of $(NH_4)_2B_4O_7$ was first prepared by dissolving 24.74 grams of H_3BO_3 in 35 cubic centimeters of 15 N NH_3 solution diluted to 100 cubic centimeters. This resulted in a solution of $(NH_4)_2B_4O_7$ plus excess NH_3. The excess NH_3 was removed by boiling, and 39.56 grams of As_2O_3 were added with stirring and heating until a clear solution resulted. A hydrate of the compound $(NH_4)_2B_4O_7 \cdot 2As_2O_3$ was prepared from the above solution by the addition of dioxane. In the indirect method, one mole of arsenous oxide is first dissolved in an amount of ammonium hydroxide in excess of two moles, the excess being required because considerable ammonia is lost during solution of the arsenous oxide. Boric acid is then added in a molar ratio to the arsenous oxide of two to one, and the solution stirred at 70 degrees centigrade until solution is achieved. As a specific example of the indirect method, 39.56 grams of As_2O_3 were stirred into a solution of 35 cubic centimeters of 15 N NH_3 dissolved in 55 cubic centimeters of water. The mixture was heated to 70 degrees centigrade and all solids dissolved. At this temperature 24.74 grams of H_3BO_3 were slowly added and stirred until dissolved. From this solution $(NH_4)_2B_4O_7 \cdot 2As_2O_3$ was precipitated by addition of dioxane.

The diammonium arseno-borate compound is many times more soluble in water than are either ammonium tetraborate or arsenous oxide. Furthermore, the ammonium compound, in its solid form, has been found to be stable above 350 degrees centigrade whereas ammonium tetraborate melts below 100 degrees centigrade and arsenous oxide sublimes at 315 degrees centigrade. As an additional test to show that diammonium arseno-borate is a true compound instead of a mere mixture or complex, 1 gram of arsenous oxide was mixed into 30 cubic centimeters of concentrated water solution of

$$(NH_4)_2B_4O_7 \cdot 2As_2O_3$$

and the mixture was boiled until clear. Thereafter the liquid was cooled until a precipitate formed and the precipitate was filtered out. The precipitate was shown to be arsenous oxide and weighed 1.0 plus or minus 0.005 grams. Thus, the amount of precipitate was exactly the same as the amount of arsenous oxide added, which shows that the molar ratio of one tetraborate to two arsenous oxide is critical.

A third preferred compound formed by combining tetraborate and arsenous oxide in the molar ratio of one to two contains the elements potassium, boron and arsenic and has the formula $K_2B_4O_7 \cdot 2As_2O_3$, various numbers of water molecules being present when the compound is in its solid form. The dipotassium arseno-borate compound may be prepared both by the direct and indirect methods as in the case of the ammonium and sodium compounds. According to the direct method, $K_2B_4O_7 \cdot 10H_2O$ (potassium tetraborate, decahydrate) and As_2O_3 are boiled together in the molar ratio of one to two, respectively. As a specific example, 32.36 grams of $K_2B_4O_7 \cdot 10H_2O$ and 39.56 grams of As_2O_3 were boiled together, while stirring, in 100 cubic centimeters of water until a clear solution resulted.

According to the indirect method, 2 moles of As_2O_3 are dissolved in a water solution containing 2 moles of KOH. Four moles of H_3BO_3 are then added and the solution boiled until clear. More specifically, 39.56 grams of As_2O_3 were dissolved, by boiling and stirring, in

100 cubic centimeters of water in which was previously dissolved 6.60 grams of 85 percent commercial KOH. To this solution were added 24.74 grams of H_3BO_3 and the mixture was heated with stirring until dissolved.

A hydrate of the salt $K_2B_4O_7 \cdot 2As_2O_3$ can be prepared from the above solutions, formed both by the direct and indirect methods, by adding an organic liquid solvent such as dioxane, and also by evaporation. Moreover, the potassium salt has been found to have a rapidly decreasing solubility with decreasing temperature and may therefore be precipitated by cooling to 10 degrees centigrade at which temperature the salt will precipitate on standing.

The dipotassium arseno-borate compound was tested, as described above in connection with the ammonium salt, and similar results were found. Thus, the

$$K_2B_4O_7 \cdot 2As_2O_3$$

compound is many times more soluble in water than are simple mixtures, and in its solid form is stable above 350 degrees centigrade, whereas potassium tetraborate melts at 100 degrees centigrade and arsenous oxide sublimes at 315 degrees centigrade. The potassium compound was also tested, as described above in connection with the ammonium compound, by dissolving one gram of arsenous oxide in a water solution of the compound, and then precipitating to recover the gram.

In addition to the pure salts such as disodium arseno-borate, dipotassium arseno-borate, and diammonium arseno-borate, it is possible to form mixed salts as indicated heretofore. One such mixed salt is sodium potassium arseno-borate ($NaKB_4O_7 \cdot 2As_2O_3$) and may be formed by adding dioxane or similar organic solvent to a water solution containing both the sodium and potassium arseno-borates. The resulting precipitate will then comprise not only the pure salts but also a substantial amount of the mixed salt. As a specific example, 19.8 grams of arsenous oxide, 2 grams of sodium hydroxide, and 2.8 grams of potassium hydroxide were mixed in 100 grams of water and the mixture boiled until the solids dissolved. 12.4 grams of boric acid were then added and the solution boiled until clear. From this solution

$$NaKB_4O_7 \cdot 2As_2O_3,\ Na_2B_4O_7 \cdot 2As_2O_3,\ \text{and}\ K_2B_4O_7 \cdot 2As_2O_3$$

were precipitated by addition of dioxane.

Although the new arseno-borate compounds have been described above as having the general formula $XYB_4O_7 \cdot 2As_2O_3$, it is a fact that since true compounds are formed the formula may also be written $XYB_4As_4O_{13}$, where XY represents Na_2, K_2, $(NH_4)_2$, etc. Thus, disodium arseno-borate would have the formula $Na_2B_4As_4O_{13}$, diammonium arseno-borate the formula $(NH_4)_2B_4As_4O_{13}$, and dipotassium arseno-borate the formula $K_2B_4As_4O_{13}$.

It is of importance that the compounds are chemical combinations of boron oxide and arsenous oxide, in addition to being chemical combinations of borate and arsenous oxide as previously stated. Just as sodium tetraborate ($Na_2B_4O_7$), for example, may also be written $Na_2O \cdot 2B_2O_3$, disodium arseno-borate may be represented by the formula $Na_2O \cdot 2B_2O_3 \cdot 2As_2O_3$. The described arseno-borate compounds are therefore seen to be chemical combination of boron oxide and arsenous oxide in equimolecular quantities, in combination with the basic oxides Na_2O, K_2O, and $(NH_4)_2O$ (theoretical).

It is contemplated that the new compounds will have substantial commercial application in a wide number of fields including the field of agricultural chemistry, and more particularly in the killing of insects, rodents, and weeds. It has already been found that disodium arseno-borate produces lethal results when applied to rodents and certain weeds. The use of the compounds in inhibiting corrosion of ferrous metal surfaces by aqueous acid solutions, particularly in oil wells, is of great importance and is set forth in detail below.

In many oil fields the production of fluids from the subsurface formation is accompanied by severe corrosion of pipe and attendant equipment which comes into contact with the fluid mixture being produced. It is generally recognized that the corrosion is mainly the result of attack on the ferrous metal surfaces by the salt water accompanying the petroleum fluids. This salt water is acidic because of the carbon dioxide and organic acids dissolved in it, and therefore dissolves iron by the formation of soluble ferrous salts. In such oil fields it is necessary to make frequent costly replacement of equipment that has failed as a result of the corrosion. As stated above, this corrosive action has been mitigated by introducing into the well a solution of arsenous oxide in aqueous alkali but this practice has frequently resulted, particularly in wells having a substantial production of carbon dioxide gas, in precipitation of the arsenous oxide onto the casing and tubing where it is useless in preventing corrosion and is a substantial menace to the oil field workers.

According to the present invention, the corrosion is mitigated by introducing into the well a composition of matter containing boron and arsenic, and more particularly arsenous oxide and a borate. Specifically, the inhibitor introduced into the well is a compound set forth in detail above and formed by combining arsenous oxide and tetraborate in the molar ratio of two to one. The compound $Na_2B_4O_7 \cdot 2As_2O_3$ and the compound $(NH_4)_2B_4O_7 \cdot 2As_2O_3$ are preferred since these compounds have high solubilities at normal temperature and will not come out of the aqueous solution when introduced into the well, regardless of the amount of carbon dioxide present. $K_2B_4O_7 \cdot 2As_2O_3$ is also satisfactory in some wells but is of lesser value since it is relatively insoluble as compared to the sodium or ammonium compounds.

The inhibitor is preferably introduced in liquid form, and in various ways depending on the physical setup at a given well. One convenient method is to pump continuously a solution of the inhibitor into the open annular space between the producing tubing and the casing. Another method is to lubricate larger quantities of the inhibitor periodically into the well annulus. The liquid can also be pumped directly into the tubing and forced down the well into the formation where it will be returned slowly over a long time period with the produced well fluid.

A preferred inhibitor solution comprises two pounds of $Na_2B_4O_7 \cdot 2As_2O_3$ dissolved in one gallon of water and having a pH of 7.9. A second preferred solution comprises three pounds of $(NH_4)_2B_4O_7 \cdot 2As_2O_3$ dissolved in one gallon of water and having a pH of 7.9. These solutions are diluted with water and introduced into the well for the purpose of inhibiting corrosion of ferrous metal surfaces, the additional water being utilized for the purpose of washing the solution to the well bottom.

The amount of inhibitor introduced is such that the water produced by the well will have an inhibitor concentration (calculated as the new compound) of from 1 to 100 parts per million (p. p. m.). Preferably, the concentration is approximately 20 parts per million since this concentration produces substantially complete corrosion inhibition with but a small amount of inhibitor.

The effectiveness of the inhibitor has been tested in the laboratory by using a salt solution or brine containing 30 grams of NaCl per liter of water. This brine was saturated with carbon dioxide to remove oxygen and to give the solution on acidity representative of that found in oil wells. The carbon dioxide saturated brine was heated to 170 degrees Fahrenheit and flowed at a slow rate past cylinders or coupons of SAE 1020 steel. A measurement of the evolved hydrogen was used to determine the corrosion rate of the steel coupons.

The following table gives the percent of corrosion inhibition for different concentrations of $Na_2B_4O_7 \cdot 2As_2O_3$, $(NH_4)_2B_4O_7 \cdot 2As_2O_3$, and $K_2B_4O_7 \cdot 2As_2O_3$ in the brine.

The percentage inhibition was calculated relative to the corrosion rate when no inhibitor was present.

	Concentration (p. p. m.)	Percent Inhibition
$Na_2B_4O_7 \cdot 2As_2O_3$	0	0
	2	72
	5	88
	20	96
	50	100
$K_2B_4O_7 \cdot 2As_2O_3$	5	87
	20	95
$(NH_4)_2B_4O_7 \cdot 2As_2O_3$	5	88
	20	96

According to the best understanding of the inventor, the corrosion inhibition effect is produced by the anion $(B_4O_7 \cdot 2As_2O_3)^{--}$ which results from ionization of the compounds as previously indicated. This anion is reduced, by a cathode reaction in the well, to form arsenic and boric acid, the metallic arsenic being plated onto the ferrous metal surfaces to produce the protective effect. The equation for this cathode reaction may be represented as follows:

$$(B_4O_7 \cdot 2As_2O_3)^{--} + 4H^+ + 2H_2O + 6e^- \rightarrow As + 4H_2BO_3^-$$

The above equation indicates that the anion breaks down into metallic arsenic without any intermediate step in which arsenous oxide is produced.

In addition to the preferred method of introducing the inhibitor into the well in aqueous solution, it may be introduced as a solid such as thte arseno-borate crystals, the amount introduced being sufficient to give the produced water an inhibitor concentration of 1 to 100 p. p. m.

Furthermore, the method of the invention may be carried out by mixing borax and arsenous oxide, for example, in powder or stick form and introducing them into the well, a reaction then occurring when the water naturally present in the well is encountered. Stated otherwise, although the inhibitor is preferably introduced in reacted form (the new compounds) it may in some instances be introduced in the form of ingredients which when dissolved in the water naturally present in the well will form the new compounds.

While the particular composition of matter and method herein described in detail are fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that they are merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended other than as defined in the appended claims.

I claim:

1. A new chemical compound represented by the formula:

$$XYB_4O_7 \cdot 2As_2O_3$$

wherein X and Y are cations selected from a group consisting of the alkali metals and ammonium.

2. A new chemical compound represented by the formula:

$$X_2B_4O_7 \cdot 2As_2O_3$$

wherein X is a cation selected from a group consisting of the alkali metals and ammonium.

3. A new chemical compound represented by the formula $Na_2B_4O_7 \cdot 2As_2O_3$.

4. A new chemical compound represented by the formula $K_2B_4O_7 \cdot 2As_2O_3$.

5. A new chemical compound represented by the formula $(NH_4)_2B_4O_7 \cdot 2As_2O_3$.

6. An inhibitor of acid attack on ferrous metal surfaces, comprising a new chemical compound represented by the formula:

$$XYB_4O_7 \cdot 2As_2O_3$$

wherein X and Y are cations selected from a group consisting of the alkali metals and ammonium.

7. An inhibitor of acid attack on ferrous metal surfaces, comprising a new chemical compound represented by the formula:

$$X_2B_4O_7 \cdot 2As_2O_3$$

wherein X is a cation selected from a group consisting of the alkali metals and ammonium.

8. An inhibitor of acid attack on ferrous metal surfaces, comprising a chemical compound having the formula $Na_2B_4O_7 \cdot 2As_2O_3$.

9. An inhibitor of acid attack on ferrous metal surfaces, comprising a chemical compound having the formula $(NH_4)_2B_4O_7 \cdot 2As_2O_3$.

10. An inhibitor of acid attack on ferrous metal surfaces, comprising a chemical compound having the formula $K_2B_4O_7 \cdot 2As_2O_3$.

11. A method of inhibiting the corrosion of ferrous metal surfaces in an oil well delivering a well fluid comprising oil, brine and carbon dioxide gas, which comprises introducing into the well bottom in a concentration effective to inhibit corrosion of ferrous metal surfaces an inhibitor containing a chemical compound represented by the formula:

$$XYB_4O_7 \cdot 2As_2O_3$$

wherein X and Y are cations selected from a group consisting of the alkali metals and ammonium.

12. A method of inhibiting the corrision of ferrous metal surfaces in an oil well delivering a well fluid comprising oil, brine and carbon dioxide gas, which comprises introducing into the well bottom in a concentration effective to inhibit corrosion of ferrous metal surfaces an inhibitor containing a new chemical compound represented by the formula:

$$X_2B_4O_7 \cdot 2As_2O_3$$

wherein X is a cation selected from a group consisting of the alkali metals and ammonium.

13. A method of inhibiting the corrosion of ferrous metal surfaces in an oil well delivering a well fluid comprising oil, brine and carbon dioxide gas, which comprises introducing into the well bottom an inhibitor compound having the formula $Na_2B_4O_7 \cdot 2As_2O_3$, said compound being introduced in an amount sufficient to give the produced water an inhibitor concentration of 1 to 100 p. p. m.

14. A method of inhibiting the corrosion of ferrous metal surfaces in an oil well delivering a well fluid comprising oil, brine and carbon dioxide gas, which comprises introducing into the well bottom an inhibitor compound having the formula $(NH_4)_2B_4O_7 \cdot 2As_2O_3$, said compound being introduced in an amount sufficient to give the produced water an inhibitor concentration of 1 to 100 p. p. m.

15. A method of inhibiting the corrosion of ferrous metal surfaces in an oil well delivering a well fluid comprising oil, brine and carbon dioxide gas, which comprises introducing into the well bottom an inhibitor compound having the formula $K_2B_4O_7 \cdot 2As_2O_3$, said compound being introduced in an amount sufficient to give the produced water an inhibitor concentration of 1 to 100 p. p. m.

References Cited in the file of this patent

UNITED STATES PATENTS

1,446,160	Cullen	Feb. 20, 1923
2,094,881	Gale	Oct. 5, 1937
2,096,266	Suhr	Oct. 19, 1937
2,319,777	Le Duc	May 25, 1943
2,596,425	Moyer et al.	May 13, 1952
2,607,744	Viles	Aug. 19, 1952

OTHER REFERENCES

Mellor: "A Comprehensive Treatise on Inorganic and Theoretical Chemistry," vol. 5, page 107.

Gmelin-Kraut: "Handbuch der Anorganischen Chemie," vol. 3.2, page 511.