FIG. 1

SYSTEMS AND METHODS FOR HEAT ACTIVATED VAPOR PHASE DELIVERY

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ABSTRACT

The invention herein described relates generally to systems and methods for heat activated vapor phase delivery systems which can be used to deliver, with increased efficacy, at least one volatilizable compound. More specifically, the invention herein relates to systems and methods for heat activated vapor phase delivery systems which use one or more heat sources to deliver, with increased efficacy, at least one volatilizable inhibiting compound (i.e., a compound or compounds which prevent the occurrence of a chemical reaction and/or physical condition or event, such as corrosion, tarnishing, oxidation, mildew, bacterial growth, etc.).
FIG. 3a

FIG. 3b

FIG. 3c

FIG. 2e
SYSTEMS AND METHODS FOR HEAT ACTIVATED VAPOR PHASE DELIVERY

FIELD OF THE INVENTION

[0001] The invention herein described relates generally to systems and methods for heat activated vapor phase delivery systems which can be used to deliver, with increased efficacy, at least one volatileizable compound. More specifically, the invention herein relates to systems and methods for heat activated vapor phase delivery systems which use one or more heat sources to deliver, with increased efficacy, at least one volatileizable inhibiting compound (i.e., a compound or compounds which prevent the occurrence of a chemical reaction and/or physical condition or event, such as corrosion, tarnishing, oxidation, mildew, bacterial growth, etc.).

BACKGROUND OF THE INVENTION

[0002] In commerce and industry today, the useful life of a variety of items may be extended and/or preserved by providing one or more suitable inhibitors. An inhibitor is a compound or group of compounds which can slow or negate the rate of decomposition, degradation and/or spoilage of a given item due to, for example, corrosion or oxidation. For example, certain metals are prone to corrosion and/or tarnishing. A suitable inhibitor, in such a case, would be a compound (or group of compounds) which acts as a corrosion and/or tarnish inhibitor thereby protecting a desired item or items from the adverse effects of its ambient environment.

[0003] Among the common indications of corrosion manifested in useful metallic articles are oxidation, pitting, tarnishing, mottling or discoloration of the surfaces of these items. These manifestations occur in metallic articles, particularly when exposed to oxygen, in either gaseous or liquid phase. Additionally, sulfides and/or chlorides (or chlorine) may cause corrosion or tarnishing problems as well. Inasmuch as both oxygen and water, including water vapor, occur normally and are available in nature, it is normally necessary to take precautions against corrosion when packaging metallic items for shipment or storage, or when subjecting such items to normal use. Metals which are frequently found to be susceptible to corrosion under normal atmospheric and ambient conditions include, but are not limited to, iron, copper, brass, aluminum, silver, and alloys of these metals.

[0004] Another example of undesirable decomposition, degradation and/or spoilage is the spoilage of food stuffs due to oxidation. Additionally, suitable protection may also be needed for valuable non-metallic items, such as precious and/or semi-precious stones and the like.

[0005] In view of the widespread need for protecting various articles from corrosion, be the articles metallic or otherwise, a variety of systems have been utilized. Such anti-corrosion systems often employ one or more of the following as components or sub-components thereof: (1) a desiccant; (2) a volatile corrosion inhibitor (VCI) or a volatile corrosion inhibiting film; and/or (3) an inert atmosphere. In a wide variety of cases, a VCI capsule is used. The use of VCI capsules permits a producer/manufacturer to place a VCI capsule in an existing packaging system, without having to redesign same, while still making sure that the products contained within the packaging are protected against corrosion, tarnish or some other form of degradation.

[0006] Such methods, although effective, are not suitable for all situations. In some situations, the need for the inhibition of a form of degradation is initially high and then lessens or declines over time. Current systems offer basically linear performance over a given amount of time and thus fail to provide adequate protection initially (and then provide surplus protection later in time). Thus, current systems are engineered to release a constant amount of inhibitor over a given life time. Such systems include foam-based VCI or anti-tarnish capsules.

[0007] Thus, there is a need for a system and method which permits the flexible delivery of differing amounts of one or more volatileizable compounds.

SUMMARY OF THE INVENTION

[0008] The present invention relates to a heat activated vapor phase delivery system which comprises: a container having at least one opening; at least one volatileizable inhibiting compound or formula, which is contained within the container; at least one heat source; and at least one removable cover, which is formed so as to cover the at least one opening of the container until the heat activated vapor phase delivery system is ready for use, wherein the at least one heat source heats the at least one volatileizable inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatileizable inhibiting compound or formula.

[0009] In accordance with another aspect of the invention, a heat activated vapor phase delivery system comprises: a container having at least one opening; at least one volatileizable corrosion inhibiting compound or formula, which is contained within the container; at least one heat source; and at least one removable cover, which is formed so as to cover the at least one opening of the container until the heat activated vapor phase delivery system is ready for use, wherein the at least one heat source heats the at least one volatileizable corrosion inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatileizable corrosion inhibiting compound or formula.

[0010] In accordance with another aspect of the invention, a method for protecting an enclosed area comprises the steps of: (A) placing at least one heat activated vapor phase delivery system into an area to be protected; (B) activating the at least one heat activated vapor phase delivery system; and (C) sealing the area to be protected thereby providing an enclosed area, wherein the heat activated vapor phase delivery system comprises: a container having at least one opening; at least one volatileizing inhibiting compound or formula, which is contained within the container; at least one heat source; and at least one removable cover, which is formed so as to cover the at least one opening of the container until the heat activated vapor phase delivery system is ready for use, wherein the at least one heat source heats the at least one volatileizing inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatileizing inhibiting compound or formula.

[0011] In accordance with another aspect of the invention, a heat activated vapor phase delivery system comprises: a container; at least one volatileizable inhibiting compound or
formula, which is contained within the container; at least one heat source; and at least one cover, wherein the cover contains therein at least one valve designed to release the at least one volatilizable inhibiting compound or formula as desired, wherein the at least one heat source heats the at least one volatilizable inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatilizable inhibiting compound or formula.

[0012] To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims. These embodiments are indicative, however, of but a few of the various ways in which the principles of the invention may be employed. Other objects, advantages and features of the invention will become apparent from the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIGS. 1a to 1d are schematic illustrations of heat activated vapor phase delivery systems according to several embodiments of the present invention;

[0014] FIGS. 2a to 2e are schematic illustrations of heat activated vapor phase delivery systems according to other embodiments of the present invention;

[0015] FIGS. 3a and 3b are schematic illustrations of heat activated vapor phase delivery systems according to yet other embodiments of the present invention;

[0016] FIG. 3c is a cross-sectional illustration of one variation of the heat activated vapor phase delivery systems of FIGS. 3a to 3b along the A'-A' lines of FIGS. 3a and 3b;

[0017] FIGS. 4a to 4c are schematic illustrations of heat activated vapor phase delivery systems according to other embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The invention herein described relates generally to systems and methods for heat activated vapor phase delivery systems which can be used to deliver, with increased efficacy, at least one volatilizable compound. More specifically, the invention herein relates to systems and methods for heat activated vapor phase delivery systems which use one or more heat sources to deliver, with increased efficacy, at least one volatilizable inhibiting compound (i.e., a compound or compounds which prevent the occurrence of a chemical reaction and/or physical condition or occurrence, such as corrosion, tarnishing, oxidation, mildew, bacterial growth, etc.). It should be noted that in the following text, range and ratio limits may be combined.

[0019] Additionally, as used throughout the text and claims, corrosion includes not only tarnishing, rusting and other forms of corrosion, but also includes any detrimental or unwanted degradation of an article to be protected. A volatile inhibitor is a compound or a mixture of compounds with a finite vapor pressure which, under a given set of conditions, can generate vapors which may or may not condense on any surface which the vapors come into contact with. Generally, the lower a compound’s or a mixture’s vapor pressure, the more difficult it is to generate vapors from such a compound or mixture.

[0020] As is noted above, the invention herein described relates to heat activated vapor phase delivery systems and methods of using same which can be used to deliver, with increased efficacy, at least one volatilizable compound (e.g., at least one volatilizable inhibiting compound). The systems of the present invention can be utilized in any situation where a volatilizable compound is desired and the use of heat is not a deterrent. Such situations can include, but are not limited to, storage tanks, septic tanks, containers (e.g., shipping containers, storage containers, reservoirs, etc.); and/or closed systems (e.g., waste disposal systems, waste disposal drums or containers, etc.)

[0021] In one embodiment, the present invention utilizes a heating means, as will be discussed in detail below, to generate a temperature in the range of about 40 degrees C. to about 90 degrees C., or about 45 degrees C. to about 85 degrees C., or even from about 50 degrees C. to about 80 degrees C. The heat source acts to increase the amount of volatilizable compound or compounds which are initially generated by the systems of the present invention by increasing the vapor pressure of the volatilizable compound(s) contained therein. In one embodiment, the heat source of the present invention increases the amount of vapor generated by the one or more volatilizable compounds by at least a factor of about 3 over the amount generated in a given period of time (e.g., one hour) at room temperature and pressure (approximately 25 degrees C. and 1 atmosphere). In another embodiment, the heat source of the present invention increases the amount of vapor generated by the one or more volatilizable compounds by a factor of at least about 5, by a factor of at least about 10, or by a factor of at least about 100, over the amount generated in a given period of time (e.g., one hour) at room temperature and pressure (approximately 25 degrees C. and 1 atmosphere).

[0022] In one embodiment, the heat source is active (i.e., maintains a minimum temperature within one of the above stated ranges) and generates the increased amount of vapor (as discussed above) for any suitable period of time. In one embodiment, this period is at least about 1 hour, or at least about 12 hours, or even at least about 1 year. In another embodiment, the heat source is active for a period of about 1 hour to about 240 hours, or about 4 hours to about 168 hours, or even about 6 hours to about 120 hours. In another embodiment, the heat source is active for a period of about 2 hours to about 1 year.

[0023] Generally, the systems, according to the present invention contain at a minimum the following components: (1) at least one heat source; (2) one or more volatilizable compounds and/or formulas; and (3) a container, which can be sealed or recirculated, which contains therein the one or more volatilizable compounds and the at least one heat source.

[0024] 1. Heat Sources:

[0025] As is noted above, the systems of the present invention contain at least one heat source. Any suitable heat source having a controllable heat output can be utilized in the present invention. Suitable heat sources include, but are not limited to, chemical heat sources (e.g., mixtures of iron powder, water, salt, activated charcoal and vermiculite)
which, when exposed to air, undergo a chemical reaction and yield excess heat and battery or fuel powered non-flame heat sources (e.g., a light bulb, a heating element, etc.). One type of heat source which, in most instances, is disfavored for use in the present invention is any type of heat source which generates a flame (e.g., a Sterno can, a Bunsen burner, a cigarette lighter, etc.). This type heat source is generally disfavored for use in the present invention because it could lead to fire hazards and the temperature of the heat output is generally difficult to control.

[0026] II. Volatilizable Compounds:

As is noted above, the systems, according to the present invention, include therein at least one volatilizable compound and/or formula. In another embodiment, the present invention includes therein at least one volatilizable inhibiting compound and/or formula. Any compound which can be volatilized can be used in the present invention, whether solid or liquid. In another embodiment, the one or more volatilizable compounds or formulas of the present invention can be contained in any suitable polymer or polymer film, foam, powder, tablet (e.g., the polymer can be a polyolefin or any suitable biodegradable polymer, such as a biodegradable polyester or copolyester polymer). Suitable types of volatilizable compounds and/or formulas include volatile corrosion inhibitors, volatile tarnish inhibitors, antioxidants, anti-mildew, anti-bacterial and/or UV-protectants.

[0028] In one embodiment, any compound which is to be utilized in the present invention should generate a sufficient partial pressure at a temperature in the range of about 40 degrees C. to about 90 degrees C., or about 45 degrees C. to about 85 degrees C., or even from about 50 degrees C. to about 80 degrees C. In another embodiment, the partial pressure of the one or more volatilizable compounds should be at least about 3 to 100 times higher than the partial pressure of the one or more volatilizable compounds at 25 degrees C.

[0029] In still another embodiment, the partial pressure of the one or more volatilizable compounds should be at least about 100 Pascals (Pa) instead of about 1 Pa, at least about 5 Pa instead of about 0.1 Pa, or even at least about 10^{-2} Pa instead of about 10^{-3} Pa, at any temperature within the above stated temperature ranges. A chart detailing vapor pressure for various inorganic and organic compounds and their partial pressures, or even greater than atmospheric pressures, at certain temperatures can be found in the CRC Handbook of Chemistry and Physics, 67th Edition, pages D-192 to D-212, which is hereby incorporated by reference for its disclosure relating to vapor pressure. Additional vapor pressure related material may also be found in the CRC Handbook of Chemistry and Physics, 77th Edition, pages B-67 to B-113, which is hereby incorporated by reference for its disclosure relating to vapor pressure.

[0030] In one embodiment, the present invention contains therein one or more volatilizable corrosion and/or tarnish inhibiting compounds or formulas.

[0031] A. Corrosion Inhibiting and Tarnish Inhibiting Compounds or Formulas:

Any suitable corrosion inhibitor can be utilized in the present invention. U.S. Pat. Nos. 4,290,912; 5,320,778; and 5,855,975 disclose vapor phase or volatile corrosion inhibitors and are incorporated herein by reference in their entirety for their teachings of such compounds. For example, useful vapor phase or volatile corrosion inhibitors include, but are not limited to, benzotriazole, and mixtures of benzotriazoles of amine salts with benzotriazole, nitrates of amine salts and C_{13}H_{25}O_{2}N.

[0033] 1. Exemplary Corrosion Inhibiting Formulas

[0034] In one embodiment, a suitable corrosion inhibiting formula for inclusion into the present invention comprises a mixture of: (1a) at least one volatile corrosion inhibitor (VCI); (1b) at least one anti-oxidant; (1c) at least one alkali or alkaline-earth metal silicate or oxide; and (1d) fumed silica.

[0035] In another embodiment, the corrosion inhibiting formula comprises a mixture of: (2a) at least one volatile corrosion inhibitor (VCI); (2b) at least one anti-oxidant; (2c) at least one alkali or alkaline-earth metal silicate or oxide; (2d) fumed silica; and (2e) at least one chemically active compound.

[0036] In yet another embodiment, the corrosion inhibiting formula comprises a mixture of: (3a) an inorganic nitrite salt; (3b) a phenol represented by the formula:

![Chemical Structure](image)

where R^1, R^2 and R^3 are selected from alkyl, aryl, alkenyl, hydroxyalkyl, hydroxyalkenyl and where the sum of carbon atoms in R^1, R^2 and R^3 is in the range of 3 to about 18; and (3c) fumed silica. All of the mixtures described above can further include additional additives.

[0038] a. Volatile Corrosion Inhibitors:

[0039] Any suitable volatile corrosion inhibitor (or vapor phase corrosion inhibitor) can be utilized in the at least one corrosion inhibiting formula contained in the present invention. As is noted above, some suitable volatile corrosion inhibitors are disclosed in U.S. Pat. Nos. 4,290,912; 5,320,778; and 5,855,975, which are all incorporated herein by reference in their entirety for their teachings of such inhibitors. For example, useful vapor phase or volatile corrosion inhibitors include, but are not limited to, triazoles and/or inorganic nitrates (e.g., nitrite salts).

[0040] In one embodiment, exemplary inorganic nitrite salts include, but are not limited to, metal nitrates, such as sodium nitrate, potassium nitrate and barium nitrate. In another embodiment, any suitable Group 1 or Group 2 nitrite (New Notation System) can be used in the at least one corrosion inhibiting formula contained in the present invention.

[0041] In another embodiment, the one or more vapor phase or volatile corrosion inhibitors utilized in the present invention can be a triazole. Exemplary triazoles include, but are not limited to, benzotriazole, tolyltriazole and/or sodium tolyltriazole.
In yet another embodiment, the vapor phase or volatile corrosion inhibitor utilized in the present invention can be any suitable mixture of two or more of the above-mentioned inhibitors.

b. Anti-Oxidants:

Any suitable anti-oxidant can be utilized in the at least one corrosion inhibiting formula contained in the present invention. Exemplary anti-oxidants include, but are not limited to, tri-substituted phenols independently substituted in the 2, 4 and 6 positions with one or more alkyl, hydroxyalkyl, aryl, alkenyl or hydroxyalkenyl groups of the general formula shown below.

In one embodiment, the sum of the carbon atoms present in the substituent groups R', R2 and R3 is in the range of 3 to about 36, or even in the range of 3 to about 18.

In another embodiment, a mixture of two or more of the above-mentioned anti-oxidants can be utilized in the at least one corrosion inhibiting formula contained in the present invention.

c. Alkali/Alkaline-Earth Metal Silicates/Oxides:

Any suitable Group 1 or 2 silicate or oxide can be utilized in the at least one corrosion inhibiting formula contained in the present invention. Exemplary silicates include lithium silicate, sodium silicate, potassium silicate and barium silicate. With regard to the silicates utilized in the at least one corrosion inhibiting formula contained in the present invention, the weight ratio of alkali or alkaline-earth metal oxide to silicate can vary. In one embodiment, this ratio of metal oxide to silicate is from about 5:1 to about 1:5. In another embodiment, the ratio of metal oxide to silicate is from about 3:1 to about 1:3.

In another embodiment, a mixture of one or more silicates can be utilized in the at least one corrosion inhibiting formula contained in the present invention. In yet another embodiment, the one or more silicates can be in a glassy or crystalline state.

In yet another embodiment, at least one alkali or alkaline-earth metal oxide is utilized in the at least one corrosion inhibiting formula contained in the present invention rather than, or in addition to, the one or more silicates discussed above. Exemplary alkali and alkaline-earth metal oxides include, but are not limited to, magnesium oxide, calcium oxide, strontium oxide and barium oxide. In another embodiment, a mixture of two or more alkali or alkaline-earth metal oxides can be utilized in the at least one corrosion inhibiting formula of the present invention.

d. Fumed Silica:

Any suitable fumed silica can be utilized in the at least one corrosion inhibiting formula contained in the present invention. Suitable fumed silicas are available under the tradenames Cab-O-Sil from Cabot Corporation and Aerosil from American Cyanamid.

e. Chemically Active Compound:

If present, the at least one chemically active compound utilized in the at least one corrosion inhibiting formula contained in the present invention can be an oxide compound, or combination thereof, which can react with one or more compounds to form compounds which are insoluble in aqueous environments. Exemplary chemically active compounds include, but are not limited to, iron oxides (both ferrous oxide and ferric oxide), cobalt oxide, nickel oxide, copper oxides (both cuprous oxide and cupric oxide) and zinc oxide.

In another embodiment, mixtures of two or more of the above-mentioned oxides can be utilized.

f. Additional Additives:

In addition to components (1a) to (1d) (or (2a) to (2c)), the at least one corrosion inhibiting formula contained in the present invention may also contain other additives, such as UV-protection agents, anti-bacterial agents, anti-mildews, etc.

In one embodiment, the one or more corrosion inhibiting formulas contained in the present invention are acid-free (i.e., the mixtures contain an amount, if any, of acidic compounds which does not adversely affect the final pH of the corrosion inhibiting formulas of the present invention). For example, in one embodiment, acid free can mean having a pH of more than about 5, or more than about 6, or even more than about 7.

In another embodiment, the one or more corrosion inhibiting formulas contained in the present invention optionally contain at least one odor-suppressing compound. Such compounds include, but are not limited to, iron oxides (both ferrous oxide and ferric oxide), cobalt oxide, nickel oxide, copper oxides (both cuprous oxide and cupric oxide), zinc oxide, magnesium oxide and calcium oxide.

G. EXAMPLES

The above corrosion inhibiting formulas are further illustrated by the following examples wherein the term “parts” refers to parts by weight unless otherwise indicated. The following examples are not meant to be limiting, rather they are illustrative of only a few embodiments within the scope of the present invention.

Examples A-1 to A-3 describe the preparation of corrosion inhibiting formulas.

Example A-1

| Sodium Nitriti | 2.5 parts |
| Sodium Silicate | 0.2 parts |
| "Ionol" | 0.5 parts |
| "Cab-O-Sil" | 0.1 parts |

1Sodium Silicate is a glassy product with a weight ratio of silica to sodium oxide of 2 (commercially available from the PQ Corporation).
2"Ionol" is 2,6-di(3-ethyl-benzyl)-4-methyl phenol (commercially available from the Uniroyal Chemical Company).
3"Cab-O-Sil" is fumed silica (commercially available from the Cabot Corporation).
Example A-2

<table>
<thead>
<tr>
<th>Compound</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Nitrite</td>
<td>2.5</td>
</tr>
<tr>
<td>Sodium Silicate</td>
<td>0.2</td>
</tr>
<tr>
<td>&quot;Cobratec TT-85&quot;</td>
<td>0.5</td>
</tr>
<tr>
<td>&quot;Ionoil&quot;</td>
<td>0.5</td>
</tr>
<tr>
<td>&quot;Cab-O-Sil&quot;</td>
<td>0.1</td>
</tr>
</tbody>
</table>

a) Cobratec TT-85 is sodium tolyltriazole, a corrosion inhibitor commercially available from the Sherwin-Williams Company.

Example A-3

<table>
<thead>
<tr>
<th>Compound</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Nitrite</td>
<td>2.5</td>
</tr>
<tr>
<td>Sodium Silicate</td>
<td>0.2</td>
</tr>
<tr>
<td>&quot;Ionoil&quot;</td>
<td>0.5</td>
</tr>
<tr>
<td>&quot;Cobratec TT-85&quot;</td>
<td>0.5</td>
</tr>
<tr>
<td>Zinc Oxide</td>
<td>1.0</td>
</tr>
<tr>
<td>&quot;Cab-O-Sil&quot;</td>
<td>0.1</td>
</tr>
</tbody>
</table>

2. Exemplary Tarnish Inhibiting Formulas

As noted above, in one embodiment, the present invention relates to systems which can contain therein at least one tarnish inhibiting formula which comprises a mixture of: (A) at least one strong alkali compound; and (B) at least one compound which yields an insoluble sulfide. This mixture can further include one or more additional additives, such as anti-oxidants, corrosion inhibitors, etc.

a. Strong Alkali Compound:

Any suitable Group 1 or 2 silicate or oxide can be utilized in the at least one tarnish inhibiting formula contained in the present invention as component (A), at least one strong alkali compound. Exemplary silicates include, but are not limited to, lithium silicate, sodium silicate, potassium silicate and barium silicate. With regard to the silicates utilized in the present invention, the weight ratio of alkali or alkaline-earth metal oxide to silicate can vary. In one embodiment, this ratio of metal oxide to silicate is from about 5:1 to about 1:5. In another embodiment, the ratio of metal oxide to silicate is from about 2.5:1 to about 1:2.5.

In another embodiment, a mixture of one or more silicates can be used in the at least one tarnish inhibiting formula contained in the present invention. In yet another embodiment, the one or more silicates can be in a glassy or crystalline state.

In yet another embodiment, the at least one alkali or alkaline-earth metal oxide is utilized in the at least one tarnish inhibiting formula contained in the present invention rather than the one or more silicates. Exemplary alkaline-earth metal oxides include, but are not limited to, magnesium oxide, calcium oxide, strontium oxide and barium oxide. In another embodiment, a mixture of two or more alkali or alkaline-earth metal oxides can be utilized in the at least one tarnish inhibiting formula contained in the present invention.

While not wishing to be bound to any one theory, it is believed that the one or more strong alkali compounds react with any hydrogen sulfide (H₂S) and/or any acid compounds present in the environment. This prevents such compounds and/or acids from passing through the polymer matrix of a polymer article which optionally contains therein a tarnish inhibiting formula, according to the present invention.

b. Compounds Which Yield Insoluble Compounds:

Any suitable compound which forms an insoluble compound, such as a sulfide (solubility of less than about 0.1 grams/liter of water) when H₂S is present, can be utilized in the at least one tarnish inhibiting formula contained in the present invention as component (B), the compound which yields an insoluble sulfide. Exemplary compounds include, but are not limited to, compounds containing iron, cobalt, nickel, copper and zinc. Mixtures of two or more such compounds can also be utilized in the at least one tarnish inhibiting formula contained in the present invention. Suitable anions for the compound according to component (B) include oxides and hydroxides.

c. Volatile Corrosion Inhibitors:

Exemplary compounds include, but are not limited to, zinc oxide, zinc hydroxide, iron oxides (both ferrous oxide and ferric oxide), iron hydroxide (Fe(OH)₃), cobalt oxide, cobalt hydroxides (both Co(OH)₂ and Co₂O₃·3H₂O), nickel oxide, nickel (II) hydroxide, copper oxides (both cuprous oxide and cupric oxide) and copper hydroxide. Mixtures of two or more of the above compounds can also be utilized as component (B).

d. Anti-Oxidants:

If desired, any suitable anti-oxidant can be utilized in the tarnish inhibiting portion of the present invention.
Exemplary anti-oxidants include, but are not limited to, tri-substituted phenols substituted in the 2, 4 and 6 positions with one or more alkyl, hydroxyalkyl, aryl, alkenyl or hydroxyalkenyl groups of the general formula shown below.

\[
\begin{align*}
R^1 & \quad \text{OH} \\
& \quad R^2 \\
& \quad R^3
\end{align*}
\]

[0082] In one embodiment, the sum of the carbon atoms present in the substituent groups \(R^1, R^2\) and \(R^3\) is in the range of 3 to about 36, or even in the range of 3 to about 18.

[0083] In another embodiment, a mixture of two or more of the above-mentioned anti-oxidants can be utilized in the tarnish inhibiting portion of the present invention.

[0084] e. Additional Additives:

[0085] In addition to components (4a) and (4b), the tarnish inhibiting formulas optionally contained in the present invention may also contain other additives such as, UV-protec tants, anti-bacterial, anti-mildews, etc.

[0086] In one embodiment, the one or more corrosion inhibiting formulas contained in the present invention are acid-free (i.e., the mixtures contain an amount, if any, of acidic compounds which do not adversely affect the final pH of the corrosion inhibiting formulas of the present invention). For example, in one embodiment, acid free can mean having a pH of more than about 5, or more than about 6, or even more than about 7.

[0087] In another embodiment, a tarnish inhibiting formula, according to the present invention, optionally contains an odor-suppressing compound. Such compounds include, but are not limited to, iron oxides (both ferrous oxide and ferric oxide), cobalt oxide, nickel oxide, copper oxides (both cuprous oxide and cupric oxide), zinc oxide, magnesium oxide and calcium oxide.

[0088] f. Examples:

[0089] The above tarnish inhibiting formulas are further illustrated by the following example wherein the term "parts" refers to parts by weight unless otherwise indicated. The following example is not meant to be limiting, rather it is illustrative of only one embodiment within the scope of the present invention.

Example C-1

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Nitrite</td>
<td>3 parts</td>
<td></td>
</tr>
<tr>
<td>&quot;fomol&quot;</td>
<td>2 parts</td>
<td></td>
</tr>
<tr>
<td>&quot;Cab-O-Sil&quot;</td>
<td>0.1 parts</td>
<td></td>
</tr>
<tr>
<td>Oleyl Alcohol</td>
<td>3 parts</td>
<td></td>
</tr>
</tbody>
</table>

III. Containers:

[0099] As is noted above, the systems of the present invention utilize a container which contains therein one or more volatile compounds and a heat source. As will become apparent from the discussion of the exemplary embodiments below, the containers of the present invention should have therein at least one opening or passage therein in order to permit the vapors generated from the volatile compound in the container to escape to an area which is exterior of the container.

[0100] In general, any suitable container can be utilized in the present invention. Suitable containers include, but are not limited to, those formed from any suitable material, such as metal (e.g., stainless steel, aluminum, etc.) or a suitable polymeric material (e.g., polyolefin polymers, such as polyethylene, polypropylene, ethylene/vinyl acetate copolymers, vinyl acetate/vinyl chloride copolymers and polyvinyl chloride). In one embodiment, the containers utilized in the present invention are impermeable to gases.

[0101] The containers of the present invention can be formed by any suitable production process, such as casting, injection molding, extrusion, forging, etc.
IV. Exemplary Embodiments:

The following discussion relates to exemplary embodiments of the present invention. However, it should be noted that the present invention is not limited thereto. Additionally, although the embodiments of FIGS. 1a to 4c illustrate only one heat source, the present invention contemplates embodiments where more than one heat source is utilized.

FIGS. 1a to 1d illustrate four different embodiments of a heat activated vapor phase delivery system, according to the present invention. Systems 100a to 100d all include a cover 102 and a container 104. Both the cover 102 and the container 104 should be impervious to any vapor generated by the one or more volatilizable compounds or formulas contained in container 104.

In systems 100a and 100c, the cover 102 is a cap or lid which can be removably attached by any suitable means to container 104 (e.g., by threads, glue, etc.). In systems 100b and 100d, the cover 102 is a piece of removable tape which is attached by any suitable means to container 104 (e.g., adhesive, heat sealing, glue, etc.).

Systems 100a and 100b further contain a chemical heat source 106 and one or more volatilizable compounds or formulas 108 (e.g., a corrosion or tarnish inhibiting compound or formula). Systems 100a and 100b may optionally contain a gas-permeable/liquid impermeable foam cap 110. The foam cap 110 is particularly useful if the one or more volatilizable compounds or formulas 108 are in liquid state since the cap can act to keep the one or more volatilizable compounds or formulas 108 contained within the confines of container 104.

Systems 100c and 100d differ from systems 100a and 100b in that the chemical heat source and the one or more volatilizable compounds or formulas in systems 100c and 100d have been mixed (rather than being in discrete layers) to yield a heat source/volatilizable compound or formula blend 112.

Once cover 102 is removed from systems 100a to 100d, the exposure of the chemical heat source contained therein to air generates the needed supply of heat to increase the initial amount of vapor generated from the one or more volatilizable compounds or formulas 108 or blends 112 contained therein. If desirable, cover 102 can be formed so as to be resealable, thereby permitting multiple partial uses of systems 100a to 100d, as desired.

FIGS. 2a to 2d illustrate other embodiments of a heat activated vapor phase delivery system according to the present invention. Systems 200a to 200d are similar to systems 100a to 100d, except that heat source 106 is provided by an electrical heat source means instead of a chemical means. Any suitable electrical heat source can be utilized in the present invention so long as the temperature generated thereby can be suitably controlled or is known to always be below a given threshold (e.g., 90 degrees C.). Suitable electrical heat sources include, but are not limited to, heating elements (with or without thermostat), light bulbs or a heat pump system.

As is shown in FIGS. 2a and 2b, heat source 106 is placed within container 104 in the area in which the one or more volatilizable compounds or formulas 108 reside. This placement permits more efficient transfer of heat to the one or more volatilizable compounds or formulas 108. In some instances, a less efficient transfer of heat may be desirable (e.g., when the one or more volatilizable compounds or formulas 108 have a very low vapor pressure). Accordingly, FIGS. 2c and 2d illustrate embodiments where heat source 106 is contained within a wall of container 104. In some instances, it may be desirable to improve the efficiency of the heat transferred from heat source 106 to the one or more volatilizable compounds or formulas 108. This can be accomplished by the optional inclusion of a heat conductor 120 (see FIG. 2c). Heat conductor 120 can be formed of any suitable material which conducts heat (e.g., a thin sheet of heat conductive metal foil, etc.).

In another embodiment, it may be desirable to mitigate the efficiency of the heat transferred from heat source 106 to the one or more volatilizable compounds or formulas 108. This can be accomplished by the optional inclusion of a heat shield 122 (see FIG. 2f). Heat shield 122 can be formed of any suitable material which acts as a heat insulator (e.g., a thin layer of ceramic material, etc.).

In systems 200a to 200d, the electrical heat sources 106 may be self contained (e.g., battery driven) or may be powered by external current. If the heat sources are to be powered externally, container 104 may have one or more openings formed therein to allow for the connection of the one or more heat sources 106 to a suitable source of electrical power. In one embodiment, the electrical heat source 106, whether internally or externally powered, may further contain an on/off switch (and related circuitry) to permit the heat source 106 to be turned on/off as desired.

Systems 200a to 200d can be activated by first permitting heat source 106 to heat up to a predetermined temperature by activating or turning on the heat source, if battery powered. Alternatively, if the heat source is externally powered, it may be necessary to connect the heat source with a power supply and/or turn on or activate the heat source. Then, cover 102 can be removed. Alternatively, cover 102 could be removed prior to activating/turning on the heat source 106.

In another embodiment, cover 102 can be replaced by a cover 102a which is both gas and liquid impermeable. Cover 102a contains at least one valve 150 designed to release one or more volatilizable compounds or formulas based on a predetermined time formula and/or when the pressure of the one or more volatilizable compounds or formulas reaches a predetermined amount within the sealed container 104 (see FIG. 2e). Cover 102a is particularly useful in the embodiments of the present invention which do not utilize chemical heat sources. This is because the use of a cover 102a, which contains therein one or more valves 150, could diminish the amount of oxygen (or other compound) which may be necessary for the functioning of a chemical heat source. In yet another embodiment, cover 102a could be both gas and liquid impermeable and one or more valves similar to those described above could be placed in any suitable location in container 104.

FIGS. 3a and 3b illustrate other embodiments of a heat activated vapor phase delivery system according to the present invention. Systems 300a and 300b are similar to systems 100a to 100d except that the one or more volatilizable compounds or formulas are contained within a foam
124 and heat source 106, which can be any suitable chemical or electrical heat source, is located near cover 102. The foam can be any suitable foam material as noted above.

[0116] In one embodiment, the foam 124, which contains the one or more volatilizable compounds or formulas, can further include therein one or more holes 126 (see FIG. 3c) to increase the surface area and reduce the mass of the foam. This in turn permits a more effective release of the one or more volatilizable compounds or formulas contained in the foam 124. The holes 126, if present, can be any suitable size or shape. In one embodiment, the holes 126 are circular in shape and have a diameter of about 0.01 mm to about 20 mm, or about 0.1 mm to about 12 mm, or even about 1 mm to about 6 mm.

[0117] If systems 300a and 300b contain a chemical heat source 106, the systems are activated in a manner similar to that of systems 100a to 100d. If systems 300a and 300b contain an electrical heat source 106, as discussed with regard to systems 200a to 200d, these systems are activated in a manner similar to that of systems 200a to 200d.

[0118] Additionally, any of the systems according to the present invention can further contain a suitable anchoring system or device so that the systems according to the present invention can be mounted on walls, ceilings, the inside tops of shipping containers, etc. Suitable anchoring systems/devices include, but are not limited to, adhesive tapes (e.g., double sided tape), adhesives (e.g., epoxy, glue, resin), and mechanical anchoring means (e.g., screws, bolts, rivets, etc.).

[0119] If the systems of the present invention are to be placed on ceilings or on the inside tops of shipping containers, it may be desirable to position the one or more heat sources 106 of the present invention in a location near cover 102 in a manner similar to that shown in FIGS. 3a and 3b. In such instances the one or more heat sources 106 can be anchored, attached and/or secured to container 104 by a variety of methods. For example, in the embodiments of FIGS. 3a and 3b, the heat source 106 may be held in place by the foam 124. Alternatively, as will be apparent to those of ordinary skill in the art, other methods can be used to make sure that the one or more heat sources 106 remain stationary in the systems according to the present invention such as mechanical and/or chemical anchoring methods or devices.

[0120] As will be appreciated by those of skill in the art, the present invention is not limited to the configurations shown in the attached Figures. Rather, other configurations are within the scope of the present invention. For example, in the embodiments of FIGS. 1a and 1b, the configuration of the chemical heat source 106 and the one or more volatilizable compounds or formulas 108 can be varied as desired. In one case, the chemical heat source 106 could be placed along some or all of the interior surfaces of container 104 with the one or more volatilizable compounds or formulas 108 being placed in the interior space of container 104 of systems 400a and 400b (see FIGS. 4a and 4b). In another instance, the chemical heat source 106 could be placed in the center of the interior space of container 104 with the one or more volatilizable compounds or formulas 108 being placed along the interior surfaces of container 104 of system 400c (see FIG. 4c).

[0121] In yet another embodiment, the one or more volatilizable compounds or formulas 108 could be dispersed within the chemical heat source 106 in a pattern such as a honeycomb pattern where the one or more volatilizable compounds or formulas 108 would occupy the cells of the honeycomb and the chemical heat source would occupy the honeycomb support structure. It should be noted that a reverse honeycomb configuration is also possible (i.e., the chemical heat source 106 occupying the cells of the honeycomb and the one or more volatilizable compounds or formulas 108 occupying the structure of the honeycomb).

[0122] Although the invention has been shown and described with respect to certain embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification. In particular with regard to the various functions performed by the above described components, the terms (including any reference to a “means”) used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary embodiments of the invention. In addition, a particular feature of the invention may have been disclosed with respect to only one of several embodiments, such feature may be combined with one or more other features of the other embodiments as may be desired and advantageous for any given or particular application.

What is claimed is:

1. A heat activated vapor phase delivery system comprising:

   a container having at least one opening;
   at least one volatilizable inhibiting compound or formula, which is contained within the container;
   at least one heat source; and
   at least one removable cover, which is formed so as to cover the at least one opening of the container until the heat activated vapor phase delivery system is ready for use,

   wherein the at least one heat source heats the at least one volatilizable inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatilizable inhibiting compound or formula.

2. The system of claim 1, wherein the container is formed from a polymer.

3. The system of claim 1, wherein the at least one volatilizable inhibiting compound or formula is selected from volatile corrosion inhibitors, volatile tarnish inhibitors, anti-oxidants, anti-mildew, anti-bacterials, UV-protectants, or mixtures thereof.

4. The system of claim 1, wherein the at least one volatilizable inhibiting compound or formula is selected from volatile corrosion inhibitors, volatile tarnish inhibitors, or mixtures thereof.

5. The system of claim 1, wherein the at least one volatilizable inhibiting compound or formula contains at least one of the following formulas:

   (1) a formula which comprises:
      (1a) at least one volatile corrosion inhibitor;
      (1b) at least one anti-oxidant;
(1c) at least one alkali or alkaline-earth metal silicate or oxide; and

(1d) fumed silica,

(2) a formula which comprises:

(2a) at least one volatile corrosion inhibitor;
(2b) at least one anti-oxidant;
(2c) at least one alkali or alkaline-earth metal silicate or oxide;
(2d) fumed silica; and

(2e) at least one chemically active compound,

(3) a formula which comprises:

(3a) an inorganic nitrite salt;
(3b) a phenol represented by the formula:

\[
\begin{array}{c}
\text{OH} \\
\text{R}^1 \\
\text{R}^2 \\
\text{R}^3
\end{array}
\]

where \( R^1, R^2 \) and \( R^3 \) are each independently selected from alkyl, aryl, alkenyl, hydroxyalkyl and hydroxyalkenyl, and where the sum of carbon atoms in \( R^2, R^3 \) is in the range of 3 to about 18; and

(3c) fumed silica, or

(4) a formula which comprises:

(4a) at least one strong alkali compound; and
(4b) at least one compound which yields an insoluble compound.

6. The system of claim 1, wherein the at least one volatile inhibiting compound or formula is contained within a foam.

7. The system of claim 1, wherein the at least one heat source is a chemical heat source.

8. The system of claim 1, wherein the at least one heat source is an electrical heat source.

9. The system of claim 1, wherein the vapor pressure of the at least one volatile inhibiting compound or formula is increased by a factor of at least about 10.

10. The system of claim 1, wherein the vapor pressure of the at least one volatile inhibiting compound or formula is increased by a factor of at least about 50.

11. A heat activated vapor phase delivery system comprising:

a container having at least one opening;
at least one volatile inhibition compound or formula, which is contained within the container;
at least one heat source; and

at least one removable cover, which is formed so as to cover the at least one opening of the container until the heat activated vapor phase delivery system is ready for use,

wherein the at least one heat source heats the at least one volatile inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatile inhibiting compound or formula.

12. The system of claim 11, wherein the at least one volatile inhibiting compound or formula further contains at least one additional volatile inhibiting compound or formula selected from volatile tarnish inhibitors, anti-oxidants, anti-mildew, anti-bacterial, UV-protectants, or mixtures thereof.

13. The system of claim 11, wherein the at least one volatile inhibiting compound or formula further contains at least one additional volatile tarnish inhibiting compound or formula.

14. The system of claim 11, wherein the at least one volatile inhibiting compound or formula contains at least one of the following formulas:

(1) a formula which comprises:

(1a) at least one volatile corrosion inhibitor;
(1b) at least one anti-oxidant;
(1c) at least one alkali or alkaline-earth metal silicate or oxide; and
(1d) fumed silica,

(2) a formula which comprises:

(2a) at least one volatile corrosion inhibitor;
(2b) at least one anti-oxidant;
(2c) at least one alkali or alkaline-earth metal silicate or oxide;
(2d) fumed silica; and

(2e) at least one chemically active compound,

(3) a formula which comprises:

(3a) an inorganic nitrite salt;
(3b) a phenol represented by the formula:

\[
\begin{array}{c}
\text{OH} \\
\text{R}^1 \\
\text{R}^2 \\
\text{R}^3
\end{array}
\]

where \( R^1, R^2 \) and \( R^3 \) are each independently selected from alkyl, aryl, alkenyl, hydroxyalkyl and hydroxyalkenyl, and where the sum of carbon atoms in \( R^2, R^3 \) is in the range of 3 to about 18; and

(3c) fumed silica, or

(4) a formula which comprises:

(4a) at least one strong alkali compound; and
(4b) at least one compound which yields an insoluble compound.
15. The system of claim 11, wherein the at least one volatilizable compound or formula is contained within a foam.

16. A method for protecting an enclosed area comprising the steps of:

(A) placing at least one heat activated vapor phase delivery system into an area to be protected;

(B) activating the at least one heat activated vapor phase delivery system; and

(C) sealing the area to be protected thereby providing an enclosed area,

wherein the heat activated vapor phase delivery system comprises: a container having at least one opening; at least one volatilizable inhibiting compound or formula, which is contained within the container; at least one heat source; and at least one removable cover, which is formed so as to cover the at least one opening of the container until the heat activated vapor phase delivery system is ready for use, wherein the at least one heat source heats the at least one volatilizable inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatilizable inhibiting compound or formula.

17. The method of claim 16, wherein the container is formed from a polymer.

18. The method of claim 16, wherein the at least one volatilizable inhibiting compound or formula is selected from volatile corrosion inhibitors, volatile tarnish inhibitors, anti-oxidants, anti-mildew, anti-bacterials, UV-protectants, or mixtures thereof.

19. The method of claim 16, wherein the at least one volatilizable inhibiting compound or formula is selected from volatile corrosion inhibitors, volatile tarnish inhibitors, or mixtures thereof.

20. The method of claim 16, wherein the at least one volatilizable inhibiting compound or formula contains at least one of the following formulas:

(1) a formula which comprises:

(1a) at least one volatile corrosion inhibitor;

(1b) at least one anti-oxidant;

(1c) at least one alkali or alkaline-earth metal silicate or oxide; and

(1d) fumed silica,

(2) a formula which comprises:

(2a) at least one volatile corrosion inhibitor;

(2b) at least one anti-oxidant;

(2c) at least one alkali or alkaline-earth metal silicate or oxide;

(2d) fumed silica; and

(2e) at least one chemically active compound,

(3) a formula which comprises:

(3a) an inorganic nitrite salt;

(3b) a phenol represented by the formula:

\[
\begin{align*}
R^1 & \quad \text{OH} \\
R^2 & \quad R^3
\end{align*}
\]

where R\(^2\), R\(^2\), and R\(^3\) are each independently selected from alkyl, aryl, alkenyl, hydroxyalkyl and hydroxyalkenyl, and where the sum of carbon atoms in R\(^2\), R\(^2\), and R\(^3\) is in the range of 3 and about 18; and

(3c) fumed silica, or

(4) a formula which comprises:

(4a) at least one strong alkali compound; and

(4b) at least one compound which yields an insoluble compound.

21. The method of claim 16, wherein the at least one volatilizable inhibiting compound or formula is contained within a foam.

22. The method of claim 16, wherein the at least one heat source is a chemical heat source.

23. The method of claim 16, wherein the at least one heat source is an electrical heat source.

24. The method of claim 16, wherein the vapor pressure of the at least one volatilizable inhibiting compound or formula is increased by a factor of at least about 10.

25. The method of claim 16, wherein the vapor pressure of the at least one volatilizable inhibiting compound or formula is increased by a factor of at least about 50.

26. A heat activated vapor phase delivery system comprising:

a container;

at least one volatilizable inhibiting compound or formula, which is contained within the container;

at least one heat source; and

at least one cover, wherein the cover contains therein at least one valve designed to release the at least one volatilizable inhibiting compound or formula as desired,

wherein the at least one heat source heats the at least one volatilizable inhibiting compound or formula thereby increasing the vapor pressure of the at least one volatilizable inhibiting compound or formula.

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