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(54) **Title**: CORROSION INHIBITING COMPOSITIONS AND COATINGS INCLUDING THE SAME

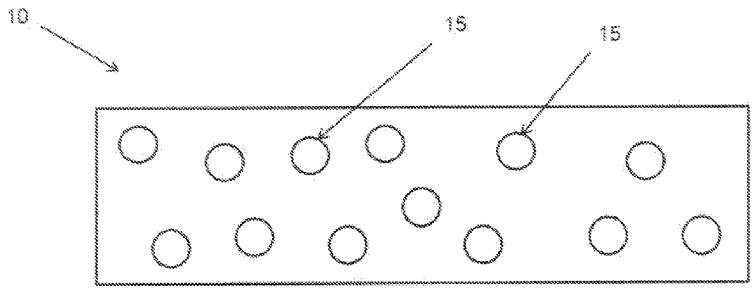


FIG. 1

(57) **Abstract**: A corrosion inhibiting composition includes a first plurality of carriers and a second plurality of carriers. The first plurality of carriers has a first carrier body which encapsulates a film-forming compound. The second plurality of carriers has a second carrier body encapsulates a corrosion inhibitor. Each of the first and second carrier bodies is formed of a degradable material. Coatings and methods for inhibiting corrosion on a metal substrate are also described herein.

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CORROSION INHIBITING COMPOSITIONS AND COATINGS INCLUDING THE SAME

TECHNICAL FIELD

[0001] The present disclosure generally relates to corrosion inhibiting compositions and methods of making and using such compositions, in particular compositions including film-forming compounds and corrosion inhibitors.

BACKGROUND

[0002] Many metals and metal alloys are subject to corrosion that causes these metals and metal alloys to lose their structural integrity. As such, methods have been developed to detect the presence of corrosion and to attempt to prevent or inhibit it.

SUMMARY

[0003] In one embodiment, a corrosion inhibiting composition includes a first plurality of carriers and a second plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body is formed of a first degradable material. Each of the second plurality of carriers includes a second carrier body and first corrosion inhibitor. The second carrier body encapsulates the first corrosion inhibitor. The first corrosion inhibitor comprises an organic compound including a ring structure. The second carrier body is formed of a second degradable material.

[0004] In another embodiment, a corrosion inhibiting composition includes a first plurality of carriers and a second plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body is formed of a first degradable material. Each of the second plurality of carriers includes a second carrier body and first corrosion inhibitor. The second carrier body encapsulates the first corrosion inhibitor. The second carrier body is formed of a second degradable material. The first plurality of carriers and the second plurality of carriers have different average outer diameters.

[0005] In still another embodiment, a corrosion inhibiting composition includes a first plurality of carriers, a second plurality of carriers, and third plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body is formed of a first degradable material. Each of the second plurality of carriers includes a second carrier body and first corrosion inhibitor. The second carrier body encapsulates the first corrosion inhibitor. The first corrosion inhibitor comprises a first organic compound including a ring structure. The second carrier body is formed of a second degradable material. Each of the third plurality of carriers includes a third carrier body and a second corrosion inhibitor. The third carrier body encapsulates the second corrosion inhibitor. The second corrosion inhibitor comprises a second organic compound including a ring structure. The second corrosion inhibitor is different from the first corrosion inhibitor. The third carrier body is formed of a third degradable material

[0006] In yet another embodiment, a coating for inhibiting corrosion on a metal surface includes a coating base and a corrosion inhibiting composition. The coating base includes an organic layer. The corrosion inhibiting composition is dispersed in the coating base. The corrosion inhibiting composition includes a first plurality of carriers and a second plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body is formed of a first degradable material. Each of the second plurality of carriers includes a second carrier body and first corrosion inhibitor. The second carrier body encapsulates the first corrosion inhibitor. The first corrosion inhibitor comprises an organic compound including a ring structure. The second carrier body is formed of a second degradable material.

[0007] In yet still another embodiment, a method for inhibiting corrosion on a metal substrate includes applying a coating to a metal substrate. The coating includes a coating base and a corrosion inhibiting composition. The coating base includes an organic layer. The corrosion inhibiting composition is dispersed in the coating base. The corrosion inhibiting composition includes a first plurality of carriers and a second plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body is formed of a first

degradable material. Each of the second plurality of carriers includes a second carrier body and first corrosion inhibitor. The second carrier body encapsulates the first corrosion inhibitor. The first corrosion inhibitor comprises an organic compound including a ring structure. The second carrier body is formed of a second degradable material.

[0008] In another embodiment, a corrosion inhibiting composition a first plurality of carriers and a second plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body has a first average diameter and is formed of a first degradable material. Each second plurality of carriers includes a second carrier body and a corrosion inhibitor. The second carrier body encapsulates the corrosion inhibitor. The second carrier body is formed of a second degradable material and has an average diameter that is larger than the first average diameter.

[0009] In yet another embodiment, a method for inhibiting corrosion on a metal substrate includes applying a coating to a metal substrate. The coating includes a coating base and a corrosion inhibiting composition. The coating base includes an organic matrix. The corrosion inhibiting composition is dispersed in the coating base. The corrosion inhibiting composition includes a first plurality of carriers and a second plurality of carriers. Each of the first plurality of carriers includes a first carrier body and a film-forming compound. The first carrier body encapsulates the film-forming compound. The first carrier body has a first average diameter and is formed of a first degradable material. Each second plurality of carriers includes a second carrier body and a corrosion inhibitor. The second carrier body encapsulates the corrosion inhibitor. The second carrier body is formed of a second degradable material and has an average diameter that is larger than the first average diameter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 illustrates an embodiment of a corrosion inhibiting composition having a plurality of carriers.

[0011] FIG. 2 illustrates one embodiment of a carrier having a carrier body and a film-forming compound.

[0012] FIG. 3A illustrates one embodiment of a carrier having a carrier body and a corrosion inhibitor.

[0013] FIG. 3B illustrates another embodiment of a carrier having a carrier body and a corrosion inhibitor.

[0014] FIG. 4 illustrates one embodiment of two carriers, one having a film-forming compound and the other carrier having a corrosion inhibitor.

[0015] FIG. 5 illustrates one embodiment of a plurality of carriers, one having a film-forming compound and the other carriers having different corrosion inhibitors.

[0016] FIG. 6 illustrates an embodiment of a coating system applied to a surface of a metal body portion of a vehicle.

[0017] FIG. 7 illustrates the Adhesion Test procedure used to measure the creep value of a test piece (e.g., metal substrate).

DETAILED DESCRIPTION

[0018] In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which is shown, by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and chemical changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims and equivalents thereof.

[0019] FIG. 1 generally illustrates a corrosion inhibiting composition 10. The corrosion inhibiting composition 10 can be applied to a metal surface (as indicated in FIG. 5), such as a vehicle body. As shown in FIG. 1, the composition 10 can include a plurality of carriers 15.

[0020] In general, each carrier 15 can be a microparticle or microcapsule that can be included in a protective coating. Such protective coating can then be applied to a metal substrate and cured thereon, so that any mechanical damage or corrosive damage to the resultant coating can cause the carrier to rupture or otherwise fail so that a repair or protective substance is released and deployed into or onto the damaged area of the coating, for example, to the exposed surface of a metal substrate. In a non-limiting example, the carrier 15 can have a substantially spherical configuration. It will be appreciated that such carriers 15 can form spherical particles, including but not limited to, microspheres, microcapsules, microparticles, nanospheres, nanocapsules and nanoparticles. However, the carrier is not limited to spherical particles, as one of ordinary skill in the art will appreciate that a variety of different shapes may be used for the carrier. Illustrative examples include, rods, fibers, tubes or elongated capsules.

[0021] FIGS. 2, 3A and 3B are enlarged, non-limiting, views of carrier 15. As shown in FIG. 2, carrier 15 can include a carrier body 17 and at least one film-forming compound 21. As shown in FIGS. 3A and 3B, carrier 15 can include a carrier body 17 and at least one organic corrosion inhibitor 20. As shown in FIG. 2, the carrier 15 is in the form of a microcapsule such that the carrier body 17 encircles and encapsulates the least one film-forming compound 21 therein. The film-forming compound 21 can be a liquid, solid, or a gas entrapped in aerogel or various combinations thereof. For certain embodiments, a film-forming compound is dissolved or dispersed in a hydrophobic substance, such as oil, or a hydrophilic substance, such as water, optionally with one or more active substances such as a corrosion inhibitor. For certain embodiments, the carrier 15 can contain only active substances such as film forming compounds 21 and organic corrosion inhibitors 20 (see FIGS. 3A and 3B).

[0022] In certain embodiments, the carrier body 17 of the carrier 15 can comprise gelatin, polyurethane, urea formaldehyde, melamine formaldehyde, melamine formaldehyde/pentaerythritol tetrakis or a suitable combination thereof. In certain embodiments, the carrier body 17 can be formed having a multi-walled shell.

[0023] Each carrier can have a substantially spherical shape with an average outer diameter up to 50 μm. In certain embodiments, each carrier has an average outer diameter ranging from about 100 nm to 15 μm. In certain embodiments, each carrier has an average outer diameter

ranging from about 0.5 μm to 10 μm. In certain embodiments, each carrier has an average outer diameter of about 5 μm or less. In certain embodiments, each carrier has an average outer diameter ranging from about 1 μm to 2 μm. The average outer diameter of each carrier can be measured using a variety of suitable techniques, including for example, optical microscopy and laser diffraction.

[0024] For carriers encapsulating a film-forming compound, such carriers can have an average diameter larger than the average diameter of a carrier encapsulating a corrosion inhibitor. In certain embodiments, a carrier comprising a film-forming compound can have an average diameter from about 3 microns to about 15 microns; in certain embodiments from about 5 microns to about 10 microns; and in certain embodiments from about 6 microns to about 8 microns. In certain embodiments, a carrier comprising a corrosion inhibitor can have an average diameter up to about 5 microns; in certain embodiments up to about 3 microns; and in certain embodiments from about 0.5 micron to about 2 microns.

[0025] Each carrier 15 can having a carrier body 17 formed from a degradable material. For example, the mechanical integrity of the carrier body 17 can break down, disintegrate or otherwise deteriorate in the presence of a base (or an alkaline), e.g., having a pH of about 8 or above, such that the carrier body 17 is breached and the film-forming compound 21 is released from the carrier 15. In certain embodiments, the carrier body 17 can be breached due to mechanical damage to the carrier body 17 (e.g., rupture, fracture, scratching, etc.). It will be appreciated that carrier body 17 for each carrier 15 can be formed from different degradable materials. It will also be appreciated that once the carrier body 17 degrades; the film-forming compound 21 can be released to the environment adjacent to the carrier 15.

[0026] Carriers 15 having carrier bodies 17 that break down under basic, or alkaline, conditions or rupture due to mechanical damage are generally known in the art. It is the interaction of alkaline conditions with functional groups of the cross-linking agent that causes carrier body 17 to break down or disintegrate under alkaline conditions. Alternatively, the film-forming compound 21 can be released mechanically, such as by scratching or applying pressure to the carrier body 17 of the carriers 15 in the corrosion inhibiting composition 10 or to a coating to which the corrosion inhibiting composition 10 is applied.

[0027] A basic, or alkaline, condition often forms in the presence of corrosion in a metal or a metal alloy, e.g., a basic condition often forms next to corrosion-induced pits, crevices, etc. For example, when a drop of salt water is applied to steel, an anodic reaction can occur to produce a rust spot, and a cathodic reaction (the reduction reaction of the oxygen in the presence of water), can occur to produce a basic condition. Therefore, when a coating, containing the corrosion inhibiting composition 10, is applied to a metal substrate, and if corrosion occurs, carrier bodies 17 of the plurality of carriers 15 can be exposed to the basic condition (e.g., alkaline) and will break down or disintegrate under the basic condition resulting from the corrosion, thereby releasing film-forming compounds 21. Corrosion can include any chemical or electrochemical process involving the deterioration or degradation of metals, including pitting, crevice corrosion, dissimilar metal corrosion, or the like.

[0028] An acidic condition often forms in the presence of corrosion in a metal or a metal alloy, e.g., an acidic condition often forms at corrosion-induced pits, crevices, etc. For example, when a drop of salt water is applied to steel, an anodic reaction can occur to produce an acidic condition, and a cathodic reaction (the reduction reaction of the oxygen in the presence of water), can occur to produce a basic condition. Therefore, when a coating, containing the corrosion inhibiting composition 10, is applied to a metal substrate, and if corrosion occurs, carrier bodies 17 of the plurality of carriers 15 can be exposed to the acidic condition and will break down or disintegrate under the acidic condition resulting from the corrosion, thereby releasing film-forming compounds 21. Corrosion can include any chemical or electrochemical process involving the deterioration or degradation of metals, including pitting, crevice corrosion, dissimilar metal corrosion, or the like. In a non-limiting example, both a mixture of alkaline and acidic degradable polymer carriers 15 can be used. It is to be understood that the same corrosion inhibitor can be used in both types of carriers or different corrosion inhibitors can be used in an acidic degradable carrier and alkaline degradable carrier.

[0029] Microcapsules as described above can be formed using a variety of suitable methods. For example, a microcapsule can be formed by forming an oil (e.g., toluene, vegetable oil) in water emulsion. A surfactant, such as xanthan gum, Attagel 40 (available from Engelhard Corporation, Iselin, N.J., USA), Petro BAF (available from Akzo Nobel Chemicals, Inc.,

Chicago, Ill., USA), and/or Reax 83 (available from MeadWestvaco Corporation, Stamford, Conn., USA) can be added to the emulsion to evenly distribute the oil in the water. A pre-polymer (e.g., an amino resin pre-polymer), a cross-linking agent having one or more ester or thioester groups that are broken down under alkaline conditions, and the organic corrosion inhibitor 20 can then be added to the oil phase. A catalyst (e.g., an inorganic acid) can be added to the water phase. The oil in water emulsion can then be heated, causing a polymerization reaction to occur at the water-oil interface, thus allowing for the formation of the carrier body 17 around film-forming compound 21 to form the carrier 15.

[0030] In a non-limiting example shown in FIG. 3A, the carrier 15 can be a microparticle including the organic corrosion inhibitor 20, and optionally one or more other active ingredients. As shown in FIG. 3A, the carrier body 17 of the carrier 15 can be a solid binder that contains (e.g., encapsulates) the organic corrosion inhibitor 20. The organic corrosion inhibitor 20 can be a liquid, solid, or a gas entrapped in aerogel or various combinations thereof. For certain embodiments, the organic corrosion inhibitor 20 can be dissolved or dispersed in a hydrophobic substance, such as oil, or a hydrophilic substance, such as water, and optionally one or more active substances such as corrosion indicator, inorganic corrosion inhibitor, film-forming compound, or various combinations thereof. For certain embodiments, the carrier 15 contains only active substances such as the organic corrosion inhibitor 20, and optionally corrosion indicators, film-forming compounds, or various combinations thereof.

[0031] The solid binder forming the carrier body 17 of the microparticle carrier 15 as shown in FIG. 3A, can comprise gelatin, polyurethane, urea formaldehyde, melamine formaldehyde, melamine formaldehyde/pentaerythritol tetrakis or a suitable combination thereof.

[0032] The microparticle carrier 15 shown in FIG. 3A can include a carrier body 17 comprising a solid binder formed from a degradable material. For example, the mechanical integrity of the solid binder can break down, disintegrate or otherwise deteriorate in the presence of a base (or an alkaline), e.g., having a pH of about 8 or above, such that the solid binder is breached and the organic corrosion inhibitor 20 is released from the carrier 15. In certain embodiments, a solid binder can be breached due to mechanical damage to the solid binder (e.g., rupture, fracture, scratching, etc.). It will be appreciated that the solid binder for each carrier

body 17 of each carrier 15 can be formed from different degradable materials. It will also be appreciated that once a solid binder degrades the organic corrosion inhibitor 20 can be subsequently released to the environment adjacent to the carrier 15.

[0033] Microparticle type carriers 15 having carrier body 17 formed of a solid binder that breaks down under basic, or alkaline, conditions or rupture due to mechanical damage are known in the art. Such microparticles can be formed using a variety of suitable methods. A basic, or alkaline, condition often forms in the presence of corrosion in a metal or a metal alloy, e.g., a basic condition often forms next to corrosion-induced pits, crevices, etc. For example, when a drop of salt water is applied to steel, an anodic reaction can occur to produce a rust spot, and a cathodic reaction (the reduction reaction of the oxygen in the presence of water), can occur to produce a basic condition. Therefore, when a coating, including the corrosion inhibiting composition 10, is applied to a metal substrate, and if corrosion occurs, the solid binders forming the carrier bodies 17 of the microparticle carriers 15 can be exposed to the basic condition (e.g., alkaline) and will break down or disintegrate under the basic condition resulting from the corrosion, thereby releasing the organic corrosion inhibitor 20. Corrosion can include any chemical or electrochemical process involving the deterioration or degradation of metals, including pitting, crevice corrosion, dissimilar metal corrosion, or the like.

[0034] In a non-limiting example shown in FIG. 3B, the carrier 15 can be a polymer particle (e.g., a polymer microparticle and a polymer nanoparticle) including the organic corrosion inhibitor 20, and optionally one or more other active ingredients. As shown in FIG. 2C, the carrier body 17 of the carrier 15 can be at least one polymer chain that contains (e.g., encapsulates) the organic corrosion inhibitor 20. In one embodiment, the carrier body 17 can be formed of a high pH responsive polymer (HPRP). The HPRP can have a number average molecular weight of about 2,500 to about 5,000. The organic corrosion inhibitor 20 can be a liquid, solid, or a gas entrapped in aerogel or various combinations thereof. For certain embodiments, the organic corrosion inhibitor 20 can be dissolved or dispersed in a hydrophobic substance, such as oil, or a hydrophilic substance, such as water, and optionally one or more active substances such as corrosion indicator, inorganic corrosion inhibitor, film-forming compound, or various combinations thereof. For certain embodiments, the carrier 15 contains

only active substances such as the organic corrosion inhibitor 20, and optionally corrosion indicators, film-forming compounds, or various combinations thereof.

[0035] The polymer particle carrier 15 shown in FIG. 3B can include a carrier body 17 comprising at least one polymer chain (e.g., HPRP with carboxylic acid end groups and a hydrophilic segment) formed from a degradable material. For example, the mechanical integrity of the polymer chain(s) can break down, disintegrate or otherwise deteriorate in the presence of a base (or an alkaline), e.g., having a pH of about 8 or above, such that the solid binder is breached and the organic corrosion inhibitor 20 is released from the carrier 15. It will be appreciated that the polymer chain(s) for each carrier body 17 of each carrier 15 can be formed from different degradable materials. It will also be appreciated that once a polymer chain degrades (e.g., breaks apart) the organic corrosion inhibitor 20 can be subsequently released to the environment adjacent to the carrier 15.

[0036] Polymer particle type carriers 15 having carrier body 17 formed of a polymer chain that breaks down under basic, or alkaline, conditions or rupture due to mechanical damage are known in the art. Such polymer particles can be formed using a variety of suitable methods, including, for example, a phase inversion method. For example, the organic corrosion inhibitor 20 can be dispersed between the entangled polymer chains that form the carrier body 17. A basic, or alkaline, condition often forms in the presence of corrosion in a metal or a metal alloy, e.g., a basic condition often forms next to corrosion-induced pits, crevices, etc. For example, when a drop of salt water is applied to steel, an anodic reaction can occur to produce a rust spot, and a cathodic reaction (the reduction reaction of the oxygen in the presence of water), can occur to produce a basic condition. Therefore, when a coating, including the corrosion inhibiting composition 10, is applied to a metal substrate, and if corrosion occurs, the polymer chains forming the carrier bodies 17 of the carriers 15 can be exposed to the basic condition (e.g., alkaline) and will break down or disintegrate under the basic condition resulting from the corrosion, thereby releasing the organic corrosion inhibitor 20. Corrosion can include any chemical or electrochemical process involving the deterioration or degradation of metals, including pitting, crevice corrosion, dissimilar metal corrosion, or the like.

[0037] In certain embodiments, an organic corrosion inhibitor can comprise from about 15% to about 50%, by weight, of a carrier; in certain embodiments, from about 20% to about 40% by weight, of a carrier; and in certain embodiments from about 20% to about 35%, by weight, of a carrier.

[0038] Once the carrier body 17 of the carrier 15, including any of those illustrated in FIGS. 2, 3A or 3B, has degraded, a repair substance and/or an anti-corrosion substance can be released.

[0039] Repair substances, such as film-forming compounds can fill voids in the original coating to seal and protect the damaged area. These film-forming compounds can be released from carriers (e.g., microcapsules or microparticles) once the encapsulant (e.g., carrier body) becomes damaged. Such suitable film-forming compounds can include a clear varnish (e.g., an acrylic varnish), epoxy resins, polar aprotic solvents, siloxane resins (e.g., polydimethylsiloxane), linseed oil, tung oil, silyl ester, iscocyanates, or combinations thereof. Other suitable film-forming compounds can include polybutenes, phenolics, phenolic varnishes, long chain polyester diluents, carrier diluents, and combinations thereof. Other suitable film-forming compounds are further described in U.S. Patent Application Publication Nos. 2006/0042504, 2008/0152815, 2012/0000810 and 2012/0052307.

[0040] Without being limited to any particular theory, an organic corrosion inhibitor can use one or more mechanisms to provide the requisite corrosion protection, including for example, absorption and adsorption. Organic corrosion inhibitors can include, but are not limited to, organo phosphonates (including, but not limited to phenyl phosphonic acid), amine compounds (including, but not limited to triethanolamine and dodecylamine), imadazole compounds (including, but not limited to benzoimidazole, and 2-phenilimidazoline), oxazole compounds, indazole compounds, triazole compounds (including, but not limited to benzotriazole), pyrazole compounds (including, but not limited to 3-Methyl-5-pyrazolone), thiazole compounds (including, but not limited to 2-Mercaptobenzothiazole), quinoline and quinolone compounds (including, but not limited to 8-Hydroxyquinoline, and 8-Hydroxyquinaldine), their derivatives, and combinations thereof. Certain corrosion inhibitors are also described in U.S. Patent Application Serial No. 13/839,895, filed March 15, 2013, which is hereby incorporated herein by reference in its entirety.

[0041] In certain embodiments, as illustrated in FIG. 4, a corrosion inhibiting composition can include a first carrier 15a and a second carrier 15b. The first carrier 15a can include a first carrier body 17a and a film-forming compound 21. The first carrier 15a can be formed from a microcapsule. The second carrier 15b can include a second carrier body 17a and a corrosion inhibitor 20b. The second carrier 15b can be formed from a microparticle.

[0042] In certain embodiments, a corrosion inhibiting composition can include a plurality of carriers, each having a carrier body and a corrosion inhibitor encapsulated by the carrier body. The corrosion inhibitor can include an organic compound including a ring structure. The carrier body can be formed of a degradable material. In a non-limiting example, the corrosion inhibitor can be a chelating agent or capable of acting as a chelating agent. For example, the corrosion inhibitor may have a plurality of donor atoms. In a non-limiting example, the corrosion inhibitor can include an organic compound such as a heterocyclic compound with an endocyclic donor atom and an exocyclic donor atom. For example, the corrosion inhibitor may include a heterocyclic compound with an exocyclic donor atom directly bonded to the heterocyclic compound (e.g., 2-Mercaptobenzothiazole and 3-Methyl-5-pyrazolone), or an exocyclic donor atom that is not directly bonded to the heterocyclic ring (e.g., 8-Hydroxyquinoline and 8-Hydroxyquinaldine). In a non-limiting example, the carrier body can comprise gelatin, polyurethane, urea formaldehyde, melamine formaldehyde/pentaerythritol tetrakis or a suitable combination thereof. In certain embodiments, the plurality of carriers can form microparticles.

[0043] In an embodiment shown in FIG. 4, the corrosion inhibiting composition 10 can include a first carrier 15a having a film-forming compound 21, a second carrier 15b including a first corrosion inhibitor 20b, and a third carrier 15c including a second corrosion inhibitor 20c that is different from the first corrosion inhibitor 20b. In certain embodiments, the corrosion inhibiting composition 10 will comprise a first plurality of carriers 15a and a second plurality of carriers 15b, and optionally a third plurality of carriers 15c.

[0044] As generally represented by FIG. 4, the second carrier 15b can include the first corrosion inhibitor 20b that is an organo phosphonate, and the third carrier 15b can include the second corrosion inhibitor 20c that is an organic compound including a ring structure. In a non-limiting example, the organo phosphonate can be a phosphonic acid derivative (e.g., phenyl

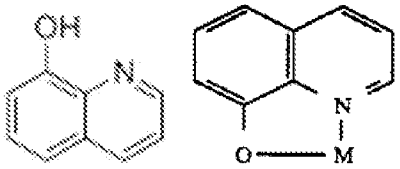
phosphonic acid). In a non-limiting example, the second corrosion inhibitor can be a chelating agent or be capable of acting as a chelating agent. For example, the second corrosion inhibitor may have a plurality of donor atoms. In a non-limiting example, the second corrosion inhibitor 20c can include a heterocyclic compound with an endocyclic donor atom and an exocyclic donor atom. For example, the second corrosion inhibitor 20c may include a heterocyclic compound with an exocyclic donor atom directly bonded to the heterocyclic ring (e.g., 2-Mercaptobenzothiazole and 3-Methyl-5-pyrazolone), or an exocyclic donor atom that is not directly bonded to the heterocyclic ring (e.g., 8-Hydroxyquinoline and 8-Hydroxyquinaldine).

[0045] In one non-limiting example, the first corrosion inhibitor can be phenyl phosphonic acid, and the second corrosion inhibitor can be 2-Mercaptobenzothiazole. In another non-limiting example, the first corrosion inhibitor can be phenyl phosphonic acid, and the second corrosion inhibitor can be 8-Hydroxyquinoline.

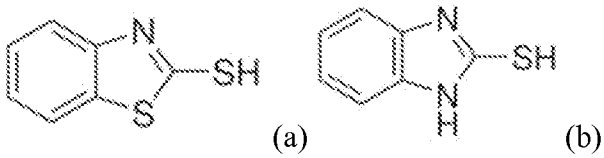
[0046] In certain embodiments, the corrosion inhibiting composition 10 of FIG. 4 can include a second carrier 15b including a first organic corrosion inhibitor 20b, and a third carrier 15c including a second organic corrosion inhibitor 20c that is different from the first organic corrosion inhibitor 20b. The second carrier 15b and the third carrier 15c may be formed as microparticles that are degradable in a corrosive environment. For example, a first carrier body 17a, a second carrier body 17b and a third carrier body 17c of the respective first carrier 15a, the second carrier 15b and the third carrier 15c can be formed of degradable materials. It will be appreciated that the first carrier body 17a, the second carrier body 17b, and the third carrier body 17c can be formed of the same or different materials. In a non-limiting example, the first corrosion inhibitor 20b and the second corrosion inhibitor 20c can be chelating agents or capable of acting as chelating agents. In a non-limiting example, the first corrosion inhibitor 20b can be an organic compound including a ring structure, and the second corrosion inhibitor 20c can be an organic compound including a ring structure. For example, the first corrosion inhibitor 20b and the second corrosion inhibitor can 20c each have a plurality of donor atoms. In a non-limiting example, one or both of the corrosion inhibitors 20b, 20c can include(s) a heterocyclic compound with an endocyclic donor atom and an exocyclic donor atom. In a non-limiting example, the first corrosion inhibitor 20b can include a heterocyclic compound with an exocyclic donor atom

directly bonded to the heterocyclic compound (including, but not limited to 2-Mercaptobenzothiazole and 3-Methyl-5-pyrazolone), and the second corrosion inhibitor can include an exocyclic donor atom that is not directly bonded to the heterocyclic compound (including, but not limited to 8-Hydroxyquinoline and 8-Hydroxyquinaldine).

[0047] In a non-limiting example, a first organic corrosion inhibitor can be 8-hydroxyquinoline (structure shown below) or a derivative thereof, 8-hydroxyquinaldine or a derivative thereof, or any combination thereof. 8-hydroxyquinoline is a bidentate binding unit containing both an oxygen donor atom (exocyclic donor), and a nitrogen donor atom (endocyclic donor). 8-hydroxyquinoline is capable of acting as a chelating agent and may have the structure shown below when bound to a metal atom, M.



[0048] The second organic corrosion inhibitor can be 2-mercaptobenzothiazole or a derivative thereof, 2-mercaptobenzimidazole or a derivative thereof, 2-(benzothiazol-2-ylsulfanyl)-succinic acid or a derivative thereof, or a combination thereof. 2-mercaptobenzothiazole is a bidentate binding unit containing both a sulfur donor atom (exocyclic donor), and a nitrogen donor atom (endocyclic donor).



(a) (b)

[0049] A variety of methods are known for forming the carrier 15, such as microcapsules and microparticles.

[0050] In certain embodiments, hydrophilic-core microcapsules, such as water-core microcapsules, can be formed from emulsions having hydrophilic-phase droplets dispersed in a

hydrophobic substance. One example is water-in-oil emulsions. Water-in-oil emulsions include hydrophilic-phase droplets (e.g., as the dispersed phase) dispersed in the hydrophobic phase (e.g., as the continuous phase). If a compound (active substance) is hydrophilic, or it can be dissolved or dispersed in a hydrophilic solvent (e.g. water), then it can be possible to encapsulate it in hydrophilic-core microcapsules. When a compound does not have sufficient solubility in the hydrophilic solvent, a co-solvent can be used to improve the dissolution of the compound and to facilitate the encapsulation process. Similarly, when a compound cannot be dispersed into the hydrophilic phase to form a reasonably stable suspension (e.g., indicated by droplets of the compound being dispersed throughout the hydrophilic phase and the compound remaining dispersed during emulsion formation and encapsulation processes), a surfactant can be used to improve the dispersion of the compound and facilitate the encapsulation process. So if a compound can be dissolved or dispersed in a hydrophilic solvent, with or without the aid of a co-solvent or a surfactant, it is possible to encapsulate it into hydrophilic-core microcapsules.

[0051] Hydrophilic-core microcapsules are typically used for encapsulating water-soluble materials, but not oil-soluble materials, such as non-polar molecules. Oil-soluble materials can be incorporated into hydrophilic-core microcapsules by first adding them to a co-solvent, and then adding the resulting solution to the hydrophilic phase. Alternatively, a surfactant can be added to the hydrophilic phase. This will dissolve or disperse the non-polar or oil-soluble reagents into the hydrophilic phase. The emulsion (e.g. water-in-oil emulsion) can then be formed by adding the hydrophilic phase to a hydrophobic phase and a reaction can be initiated to encapsulate the oil, with the active substance dissolved or dispersed therein, into the core of the hydrophilic-core microcapsules.

[0052] In general, oil-core as well as water-core microcapsules can formed to include a film-forming compound 21 within the core, being encapsulated by a carrier body 17, such as by a polymeric shell (e.g., see FIG. 2). Alternatively, the film-forming compound 21 in an oil-core microcapsule can be dissolved or dispersed in a hydrophobic substance, such as oil, with or without the aid of a co-solvent or a surfactant. The film-forming compound 21, of a water-core microcapsule, can be dissolved or dispersed in water, with or without the aid of a co-solvent or the aid of a surfactant. Other active ingredients including, but not limited to, a dye, a corrosion

indicator, an inorganic corrosion inhibitor, a film-forming compound, or various combinations thereof may be included within the carrier body 17.

[0053] The polymeric shell or solid binder of either oil-core or water-core microcapsules or microparticles can include a polymer formed from an encapsulant-forming compound (e.g., precursor) that can include a cross-linking agent having one or more ester and mercapto groups and/or a film-forming pre-polymer. In certain embodiments, an encapsulant-forming compound can include about 5 to about 75 percent (e.g., about 20 to about 50 percent) by weight of a cross-linking agent and about 25 to about 95 percent (e.g., about 50 to about 80 percent) by weight of a film-forming pre-polymer. Examples of the cross-linking agent include, but are not limited to, pentaerythritol tetrakis(2-mercaptoacetate) or compounds with similar structure (e.g., pentaerythritol tetrakis(3-mercaptopropionate) (PTT), pentaerythritol, dipentaerythritol, dipentaerythritol pentaacrylate tetra(mercaptoacetate), pentaerythritol tetra(acrylate), and their derivatives. As described herein, examples of the film-forming pre-polymer can include, but are not limited to, urea formaldehyde pre-polymer resin (e.g., butylated urea-formaldehyde resin, such as CYMEL® U80), melamine formaldehyde resin, polyurethane pre-polymers, polyols, or film-forming monomers, such as urea and formaldehyde solution, melamine and formaldehyde solution, isocyanates and various glycols, etc. The encapsulant-forming compound can form the shells of the oil-core as well as the water-core microcapsules, or the solid binders of microparticles as described herein.

[0054] The microcapsule shell of either oil-core or water-core microcapsules can include one or more chemical bonds due to the ester group in the cross-linking agent that are cleavable (e.g., broken down) at ambient temperature when the surrounding pH changes due to the occurrence of a corrosion process. For example, the ester groups can undergo an irreversible hydrolysis reaction under basic pH, e.g., when exposed to an alkali.

[0055] Cross-linking agents that have three or four functional groups, such as pentaerythritol tetrakis(2-mercaptoacetate), penta erythritol tetrakis(3-mercaptopropionate) (PTT), pentaerythritol, dipentaerythritol, dipentaerythritol pentaacrylate tetra(mercaptoacetate), and pentaerythritol tetraacrylate can also provide chemical resistance (e.g. solvent resistance) to the microcapsule shells.

[0056] It will be appreciated that a number of suitable techniques are available to form the microcapsules and microparticles as described herein, including those methods further described in U.S. Patent Nos. 7,569,625, 7,790,225 and U.S. Patent Application Publication Nos. 2010/0320421, 2010/0305234, 2012/0207921 and 2013/0017612.

[0057] In certain embodiments, corrosion inhibitors once released from respective carriers (e.g., microparticles/microcapsules) can adhere or attach to an exposed surface of a metal substrate (e.g., steel door of an automobile) to provide an anti-corrosion barrier. In certain embodiments, such organic corrosion inhibitors can be absorbed or adsorbed into the surface of the metal substrate providing effective corrosion resistance. In certain embodiments, corrosion inhibiting compositions described herein can also be added to a coating base to form a protective coating which can be applied to these metal substrates.

[0058] As shown in FIG. 6, surface 26 of a metal substrate 30 is shown overlaid with multiple layers of coatings 12, 14, 16 and 18 (e.g., paints), collectively indicated as 40, with layer 18, immediately adjacent to the surface 26 of a metal substrate 30, incorporating carriers 15 comprising either film-forming compounds 21 or corrosion inhibitors 20. Metal substrate 30 can, for example, be an outer door panel of a vehicle (e.g., automobile). For coating systems, self-healing or protective coatings can be fabricated by adding carriers containing at least one "self-healing" compound (including, for example, corrosion inhibitors) to commercially available paint primers. Paint primers can include cathodic electrodeposition coatings. Such carriers can release the self-healing compound or compounds when the coating system is damaged. Such damage can occur when the coating is mechanically damaged or suffers corrosive damage.

[0059] Coatings, like paint, can include a mixture of solids and a suitable binder, possibly also incorporating a solvent, which can generally be applied to a surface as a thin liquid layer and forms a closely adherent coating on the surface when the liquid layer is “cured”. Paint formulations vary widely. For example, a solvent can be an organic liquid, or water or can be eliminated entirely by applying the paint solids in powder form, relying on electrostatic attraction to build a thin layer. Many automotive paints employ water as a solvent and are referred to as “water-based”. Irrespective of the solvent however, in one example, automotive paints can be cured by exposure to heat in a paint bake oven.

[0060] Automotive coatings 40 can include a single layer or comprise multiple layers (e.g., four layers represented as layers 12, 14, 16 and 18 in FIG. 4). In general, layer 18 immediately adjacent to surface 26 of a metal substrate 30 can be generally intended to provide corrosion protection once the automotive coatings 40 have suffered damage. One method of applying layer 18 can be via electrodeposition (or e-coating), but it will be appreciated by one skilled in the art, that a variety of other suitable coating techniques to apply layer 18 can be employed (e.g., spraying, brushing, rolling, etc.). Subsequent layers can include: a primer-surfacer, such as represented by 16, to smooth out surface irregularities, improve stone-chip performance, and help protect against visible and UV light; a basecoat, such as represented by 14, to provide color and aesthetic effects; and a clearcoat, such as represented by 12, to provide primary protection against environmental effects and imparts gloss and depth to the overall paint finish. These three coatings can be applied as liquid sprays. All three coatings can be applied without intermediate high temperature exposure or cure, a procedure commonly described as 'wet on wet', and cured in a single paint bake oven. However, layer 18 can be cured separately in a separate paint bake oven prior to applying the remaining layers. Thus, typical automobile painting practice will expose painted parts to the elevated temperatures required for paint baking at least twice. However, it will be appreciated that there are a variety of suitable methods and techniques of applying coatings (e.g., paint layers) to surfaces of a metal body part of a vehicle.

[0061] The coating of layer 18 can include a coating base 19 and one or more additives such as a plurality of carriers 15 (e.g., microcapsules and microparticles). The coating base 19 can be a solvent, such as an aliphatic hydrocarbon (e.g., aliphatic petroleum distillates). Other such coating bases 19 (e.g., paint primers) can include greases, lubricants, varnishes, lacquers, shellacs, waxes, polishes, polyurethanes, oil-based enamels, enamel undercoater, latex acrylics, acrylic-based formulations, epoxy-based formulations (e.g., epoxy isocyanate resins), and other suitable combinations thereof. Other suitable coating bases are described in U.S. Patent Nos. 5,070,174, 7,612,152 and 7,723,405. Carriers 15 can be dispersed into a coating base 19 using a variety of suitable techniques (e.g., by mixing, chemical dispersion agents, etc.). Suitable methods of dispersing microcapsules into a coating base are described in U.S. Patent Application Publication No. 2011/0064941. A coating can comprise about 0.1% by weight or more of carriers. In certain embodiments, a coating can comprise about 0.5% by weight or more of

carriers; in certain embodiments, about 1.0% by weight or more of carriers; in certain embodiments, about 2.5% by weight or more of carriers; in certain embodiments, about 5.0% by weight or more of carriers; in certain embodiments, about 7.5% by weight or more of carriers; and in certain embodiments, about 10% by weight or more of carriers. It will be understood that a coating can include materials or substances in addition to the coating base and carriers. For example, a coating can include one or more agents that facilitate improvements in the properties of the coating, or a coating can include a filler to increase the volume or mechanical integrity of the coating.

[0062] In certain embodiments, a coating base can include a copolymer that includes an epoxy-group, such as an epoxy resin. Epoxy-groups can have a molecular weight of about 100 or more; in certain embodiments, of about 500 or more; in certain embodiments, of about 750 or more; in certain embodiments, of about 1,000 or more; in certain embodiments, of about 1,250 or more; in certain embodiments, of about 1,500 or more; and in certain embodiments of about 2,000 or more. Epoxy-groups can have a molecular weight of about 100,000 or less; in certain embodiments, of about 50,000 or less; in certain embodiments, of about 20,000 or less; in certain embodiments, of about 15,000 or less; in certain embodiments, of about 10,000 or less; in certain embodiments, of about 7,500 or less; in certain embodiments, of about 5,000 or less; and in certain embodiments of about 4,000 or less. It will be appreciated that a number of techniques are known to calculate the molecular weight of suitable epoxy-groups and copolymers.

[0063] A coating base can include the dry portion of a coating which does not include the carriers. A coating can comprise about 75% by weight or more of a coating base. In certain embodiments, a coating can comprise about 80% by weight or more of a coating base; in certain embodiments, about 85% by weight or more of a coating base; in certain embodiments, about 90% by weight or more of a coating base; in certain embodiments, about 95% by weight or more of a coating base; in certain embodiments, about 97.5% by weight or more of a coating base; in certain embodiments, about 99% by weight or more of a coating base; in certain embodiments, about 99.5% by weight or more of a coating base; and in certain embodiments, about 99.9% by weight or more of a coating base.

[0064] A coating can have a thickness of about 5 μm or more; in certain embodiments, of about 10 μm or more; in certain embodiments, of about 15 μm or more; in certain embodiments, of about 25 μm or more; in certain embodiments, of about 50 μm or more; in certain embodiments, of about 100 μm or more; in certain embodiments, of about 150 μm or more; in certain embodiments of about 200 μm or more; and in certain embodiments of about 300 μm or more. In certain embodiments, a coating can have a thickness of about 10 μm to about 100 μm. In certain embodiments, a coating can have a thickness of about 5 μm to about 25 μm.

[0065] To assist in locating corrosive damage to a coating, corrosion indicators can also be included as an encapsulate in a carrier. Suitable corrosion indicators can include a pH indicator that changes color over the alkaline region (e.g., pHs above about 8), such as phenolphthalein. Other suitable corrosion indicators can include ones that fluoresce, such as 7-hydroxycoumarin or coumarin, in the presence of or upon the oxidation of a metal or in the presence or upon the formation of a metal cation complex.

[0066] In certain embodiments, where a coating is applied, carriers can include one or more film-forming compounds, corrosion inhibitors, corrosion indicators, or various combinations thereof. For certain embodiments, if a coating is exposed to trauma that carriers to break or rupture, a film-forming compound in the carrier can be released to cover at least a portion of the surface area suffering the trauma and then acts to reduce the degree of any exposed metal of corroding. For certain embodiments, a corrosion inhibitor in a carrier can also be released to act to further reduce the degree of corrosion of any exposed metal.

[0067] Note that if corrosion occurs at locations away from the trauma location due to small breaks in the coating, such as chips, or other coating defects, corrosion inhibitors and film-forming compounds can be released due to encapsulants breaking down in the presence of the basic condition, resulting from the corrosion.

[0068] In certain embodiments, a portion of carriers in a coating can contain corrosion inhibitors and another portion of carriers in the coating can contain film-forming compounds. In certain embodiments, a portion of carriers in a coating can contain corrosion inhibitors, another portion of carriers in the coating can contain film-forming compounds, and yet another portion of

carriers in the coating can contain corrosion indicators. For certain embodiments, carriers having different contents are randomly distributed within a coating base so that carriers having the different functions of indicating, inhibiting, and/or film-forming can be adjacent each other, as well as carriers having like functions being adjacent to each other. For certain embodiments, the different functions of encapsulates can be incorporated into a coating by encapsulating different encapsulates into the same carriers.

[0069] In an embodiment, the corrosion inhibiting composition 10 may be applied in an organic matrix between two substrates. In a non-limiting example, the organic matrix may be an adhesive. In a non-limiting example, the substrates may be different metals or metal alloys such as aluminum and steel. In another non-limiting example, one substrate may be a metal or metal alloy and the other substrate may be a polymeric substrate. The polymeric substrate may include fiber reinforcements.

Procedures

A. Hot Salt Water Test

[0070] The hot salt water test can measure the amount of corrosion suffered by a metal substrate by measuring the amount of creep that occurs at the tested area.

[0071] To measure the amount of creep suffered by a test piece (e.g., metal substrate), an X-cut must first be made to the test piece, such that the X-cut reaches the base material of the test piece. A cutting knife shall be used to make the X-cut. The X-cut shall have a cross angle from 60° to 90°. The cutting knife shall be SK2 and have a hardness of HV 820+/-30. Verify the X-cut by applying electric current. Immerse the test piece in 5 wt% NaCl solution at 55°C in a glass container, and seal the container tightly. After 240 hours, remove the test piece from the container, then immediately rinse and wipe it lightly with a soft cloth. Check test piece for any rust, blisters or peeling. If rust or blister is found, measure the blister width. Then immediately attach a piece of adhesive tape to the flaw area, and peel it off in the manner specified in Adhesion Test (see below). The adhesive tape shall be cellophane and be 12 or 24 mm in width (e.g., Nichiban Cellotape). If peeling is found, measure the maximum peeling width, and that

should be the peeling width. Record either the blister width or the peeling width, whichever is larger, as the blister width/peeling width, otherwise known as the creep value (measured in mm).

[0072] In certain embodiments, a coating exhibits a creep value according to the Hot Salt Water Test of about 0.8 mm or less; in certain embodiments, about 0.6 mm or less; in certain embodiments, about 0.4 mm or less; in certain embodiments, about 0.2 mm or less; and in certain embodiments, that is negligible (essentially zero).

B. Adhesion Test

[0073] Attach a 12 or 24 mm wide piece of cellophane adhesive tape (e.g., Nichiban Cellotape) to the coating film surface of a test piece carefully not to leave any bubble between them. Hold one edge of the adhesive tape so that the angle between the adhesive face of the tape and the test piece is approximately 45° as shown in Figure 7, and peel the tape off the test piece rapidly in the same direction.

C. Salt Spray Test

[0074] The salt spray test can measure the amount of corrosion suffered by a metal substrate by measuring the amount of creep that occurs at the tested area.

[0075] To measure the amount of creep suffered by a test piece (e.g., metal substrate), an X-cut must first be made to the test piece, such that the X-cut reaches the base material of the test piece. A cutting knife shall be used to make the X-cut. The X-cut shall have a cross angle from 60° to 90°. The cutting knife shall be SK2 and have a hardness of HV 820+/-30. Verify the X-cut by applying electric current. Affix the test piece on a salt spray tester at 15° to 30° to the vertical line, and subject it to spraying of 5.0 wt % NaCl solution for 960 hours. The salt spray tester shall conform to ASTM B117 standard. The salt spray tester shall have the test conditions as shown in the table below.

Tester operation method	Continuous
Test chamber	35 ± 1°C
Air saturator temperature	47 ± 1°C
Relative humidity of test chamber	95 to
Spraying pressure	70 to 180 kPa / 0.7 to 1.8 kgf/cm^2
Amount of solution collected from	0.85 to 2.0 mL/hour for 80 cm^2
pH of solution made by spraying	6.5 to 7.2

[0076] After the subjecting the test piece to the salt spray tester, rinse the test piece and clear the corrosion product using a sponge or scrubbing cloth. Measure the width of the largest swollen area of the X-cut. After leaving the test piece at room temperature for two hours, check the film peeling property by attaching a 12 or 24 mm wide adhesive tape (e.g., Nichiban Cellotape) and peeling it off as specified in Adhesion Test described above. Measure the width of the largest area of the coating film peeled with the tape. Record the width of either the blistered area or peeled area, whichever is larger, as the creep value (measured in mm).

[0077] In certain embodiments, a coating exhibits a creep value according to the Salt Spray Test of about 1.6 mm or less; in certain embodiments, about 1.3 mm or less; in certain embodiments, about 1.1 mm or less; in certain embodiments, about 1.0 mm or less; and in certain embodiments, about 0.8 mm or less.

Examples

[0078] For the examples provided below, an epoxy-based coating (e.g., film layer) having a plurality of carriers (some with corrosion inhibitors and some without) was applied (baked at 170°C for 20 minutes) to a steel sample formed from zinc phosphated steel. The coatings were applied using a draw down bar method to a thickness of 25 microns. The epoxy-based coating included a coating base formed from a BPA epoxy resin, isocyanate and methyl isobutyl ketone (MIBK). The carriers having film-forming compounds were formed as microcapsules. The plurality of microcapsule carrier bodies were formed of polyurethane/urea formaldehyde. The average outer diameter of the film forming microcapsules were 5μm. The carriers having corrosion inhibitors were formed as microparticles. The plurality of microparticle carrier bodies were formed of melamine formaldehyde/pentaerythritol tetrakis. The average outer diameter of

the corrosion inhibiting microparticles were 1μm. The amount of carrier in each coating was provided as a % wt. of the coating and was measured on a dry basis. A creep value was measured and recorded three times using the Hot Salt Water Test and the Salt Spray Test for the comparative and inventive examples, and the average of those three trials was provided below in Table 1.

TABLE 1

Coatings	Corrosion inhibitor(s)	Film-Forming Compound	Amount of carrier in coating (% wt. on a dry basis)	Hot Salt Water Test Creep Value (mm)	Salt Spray Test Creep Value (mm)
Comparative Example A	None	None	0	0.8	1.7
Comparative Example B	None	50/50 Epoxy Resin and Ethyl Phenyl Acetate Blend	5	1.1	1.2
Comparative Example C	None	50/50 Epoxy Resin and Ethyl Phenyl Acetate Blend	2.5	0.5	1.1
Comparative Example D	None	50/50 Epoxy Resin and Ethyl Phenyl Acetate Blend	1.0	0.2	1.3
Comparative Example E	None	50/50 Alkyd Resin and Ethyl Phenyl Acetate Blend	5	1.5	1.5
Comparative Example F	None	50/50 Alkyd Resin and	2.5	0.7	1.4

		Ethyl Phenyl Acetate Blend			
Comparative Example G	None	50/50 Alkyd Resin and Ethyl Phenyl Acetate Blend	1.0	0.2	1.1
Inventive Example H	8-Hydroxyquinoline/ 2-Mercaptobenzothiazole	50/50 Epoxy Resin and Ethyl Phenyl Acetate Blend	4/1/2.5*	negligible	1.2
Inventive Example I	8-Hydroxyquinoline/ 2-Mercaptobenzothiazole	50/50 Alkyd Resin and Ethyl Phenyl Acetate Blend	4/1/2.5*	negligible	1.2

* Indicates the individual % wt. for each corrosion inhibitor and film-forming compound, and total % wt. can be calculated by adding the values together.

[0079] As illustrated in Table 1, Comparative Examples A-G each exhibited creep values according to the Hot Salt Water Test described herein of 0.2 mm or greater. Inventive Examples H and I each exhibited a negligible (essentially zero) creep value according to the Hot Salt Water Test described herein.

[0080] Also shown in Table 1, Inventive Examples H and I also maintained creep values according to the Salt Spray Test described herein at least as low as any of the Comparative Examples A-G.

[0081] Inventive Examples H and I provide alternatives to traditional coatings to protect metal substrates, and offer substantial improvements in preventing or inhibiting corrosion.

[0082] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as "40 mm" is intended to mean "about 40 mm."

[0083] It should be understood that every maximum numerical limitation given throughout this specification includes every lower numerical limitation, as if such lower numerical limitations were expressly written herein. Every minimum numerical limitation given throughout this specification will include every higher numerical limitation, as if such higher numerical limitations were expressly written herein. Every numerical range given throughout this specification will include every narrower numerical range that falls within such broader numerical range, as if such narrower numerical ranges were all expressly written herein.

[0084] All documents cited in the Detailed Description are, in relevant part, incorporated herein by reference; the citation of any document is not to be construed as an admission that it is prior art with respect to the present invention. To the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0085] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

WHAT IS CLAIMED IS:

1. A corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and a first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, the first corrosion inhibitor comprising an organic compound including a ring structure, wherein the second carrier body is formed of a second degradable material.

2. The corrosion inhibiting composition of claim 1, wherein the organic compound comprises a heterocyclic compound.

3. The corrosion inhibiting composition of claim 1, wherein the organic compound comprises a chelating agent.

4. The corrosion inhibiting composition of claim 2, wherein the heterocyclic compound includes an endocyclic donor atom and an exocyclic donor atom.

5. The corrosion inhibiting composition of claim 4, wherein the exocyclic donor atom is directly bonded to the ring structure of the heterocyclic compound.

6. The corrosion inhibiting composition of claim 4, wherein the exocyclic donor atom is not directly bonded to the ring structure of heterocyclic compound.

7. The corrosion inhibiting composition of claim 2, wherein the heterocyclic compound comprises one or more of 2-mercaptobenzothiazole, 2-mercaptobenzimidazole, 2-(benzothiazol-2-ylsulfanyl)-succinic acid, 8-hydroxyquinoline, 8-hydroxyquinaldine, and any combination thereof.

8. The corrosion inhibiting composition of claim 1, wherein the first corrosion inhibitor comprises one or more of a imidazole compound, a triazole compound, a pyrazole compound, a

thiazole compound, a oxazole compound, an indazole compound, a quinoline compound, a quinolone compound, derivatives of each, and any combination thereof.

9. The corrosion inhibiting composition of claim 1, further comprising a third plurality of carriers, each comprising a third carrier body and a second corrosion inhibitor, the third carrier body encapsulating the second corrosion inhibitor, wherein the third carrier body is formed of a third degradable material.

10. The corrosion inhibiting composition of claim 9, wherein the second corrosion inhibitor comprises an organic compound including a ring structure.

11. The corrosion inhibiting composition of claim 10, wherein the organic compound comprises a heterocyclic compound.

12. The corrosion inhibiting composition of claim 9, wherein the first corrosion inhibitor includes a thiazole compound, an imidazole compound, or any combination thereof.

13. The corrosion inhibiting composition of claim 12, wherein the first corrosion inhibitor includes 2-mercaptobenzothiazole, 2-mercaptobenzimidazole, or any combination thereof.

14. The corrosion inhibiting composition of claim 9, wherein the second corrosion inhibitor includes a quinolone, a quinolone derivative, or any combination thereof.

15. The corrosion inhibiting composition of claim 14, wherein the second corrosion inhibitor is 8-hydroxyquinoline, 8-hydroxyquinaldine, or any combination thereof.

16. The corrosion inhibiting composition of claim 1, wherein the film-forming compound comprises one or more of clear varnish, urethanes, epoxy resins, polar aprotic solvents, siloxane resins, alkyd resins, linseed oil, tung oil, silyl ester, iscocyanates, or combinations thereof.

17. A coating for inhibiting corrosion on a metal substrate, the coating comprising the corrosion inhibiting composition of claim 1, wherein the coating exhibits a creep value of about 0.1 mm or less according to the Hot Salt Water Test described herein.

18. The coating of claim 16 exhibits a creep value of about zero.

19. A coating for inhibiting corrosion on a metal substrate, the coating comprising the corrosion inhibiting composition of claim 1, wherein the coating exhibits a creep value of about 1.2 mm or less according to the Salt Spray Test described herein.

20. The coating of claim 18 exhibits a creep value of about 1.1 mm or less according to the Salt Spray Test described herein.

21. A corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film forming compound, the first carrier body encapsulating the film forming compound, wherein the first carrier body is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, wherein the second carrier body is formed of a second degradable material, and wherein the first plurality of carriers and the second plurality of carriers have different average outer diameters.

22. The corrosion inhibiting composition of claim 21, wherein the ratio of the first plurality of carriers to the second plurality of carriers is greater than 1.

23. The corrosion inhibiting composition of claim 21, wherein the ratio of the first plurality of carriers to the second plurality of carriers is less than 1.

24. The corrosion inhibiting composition of claim 21, wherein the ratio of the first plurality of carriers to the second plurality of carriers is about 1.

25. The coating of claim 21, wherein each of the first plurality of carriers comprises an average outer diameter that ranges from about 1 μm to about 2 μm.

26. The coating of claim 21, wherein each of the second plurality of carriers comprises an average outer diameter that ranges from about 0.1 μm to about 0.5 μm.

27. The coating of claim 21, wherein each of the second plurality of carriers comprises an average outer diameter ranges from about 3 μm to about 5 μm.

28. A corrosion inhibiting composition comprising:

a first plurality carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body is formed of a first degradable material;

a second plurality of carriers, each comprising a second carrier body and a first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, the first corrosion inhibitor comprising a first organic compound including a ring structure, wherein the second carrier body is formed of a second degradable material; and

a third plurality of carriers, each comprising a third carrier body and a second corrosion inhibitor, the third carrier body encapsulating the second corrosion inhibitor, the second corrosion inhibitor comprising a second organic compound including a ring structure, wherein the second corrosion inhibitor is different from the first corrosion inhibitor, and wherein the third carrier body is formed of a third degradable material.

29. The corrosion inhibiting composition of claim 28, wherein the first plurality of carriers each form microcapsules.

30. The corrosion inhibiting composition of claim 28, wherein the first plurality of carriers and the second plurality of carriers each form microparticles.

31. The corrosion inhibiting composition of claim 28, wherein the first corrosion inhibitor includes 2-mercaptobenzothiazole, 2-mercaptobenzimidazole, or any combination thereof.

32. The corrosion inhibiting composition of claim 28, wherein the second corrosion inhibitor includes a quinolone, a quinolone derivative, or any combination thereof.

33. The corrosion inhibiting composition of claim 32, wherein the second corrosion inhibitor is 8-hydroxyquinoline, 8-hydroxyquinaldine, or any combination thereof.

34. A coating for inhibiting corrosion on a metal substrate, the coating comprising the corrosion inhibiting composition of claim 28, wherein the coating exhibits a creep value of about 0.1 mm or less according to the Hot Salt Water Test described herein.

35. The coating of claim 34 exhibits a creep value of about zero.

36. A coating for inhibiting corrosion on a metal substrate, the coating comprising the corrosion inhibiting composition of claim 28, wherein the coating exhibits a creep value of about 1.2 mm or less according to the Salt Spray Test described herein.

37. The coating of claim 36 exhibits a creep value of about 1.1 mm or less according to the Salt Spray Test described herein.

38. A coating for inhibiting corrosion on a metal substrate, the coating comprising:

a coating base comprising an organic layer; and

a corrosion inhibiting composition dispersed in the coating base, the corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and a first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, the first corrosion inhibitor comprising an organic compound including a ring structure, wherein the second carrier body is formed of a second degradable material.

39. The coating of claim 38, wherein the organic layer comprises a copolymer that includes an epoxy-group, the epoxy-group having a molecular weight from about 100 to about 10,000.

40. The coating of claim 39, wherein the epoxy-group comprises a molecular weight from about 1,000 to about 5,000.

41. The coating of claim 38, wherein the first and second degradable materials degrade when exposed to alkaline conditions.

42. The coating of claim 38, wherein the first and second degradable materials degrade when mechanically damaged.

43. The coating of claim 38 having a thickness of about 10 μm to about 100 μm.

44. The coating of claim 43 having a thickness of about 5 μm to about 25 μm.

45. A vehicle having metal body portions coated with the coating of claim 38.

46. A method for inhibiting corrosion on a metal substrate, the method comprising:

applying a coating to a metal substrate, the coating comprising,

a coating base comprising an organic layer; and

a corrosion inhibiting composition dispersed in the coating base, the corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and a first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, the first corrosion inhibitor comprising an organic compound including a ring structure, wherein the second carrier body is formed of a second degradable material.

47. The method of claim 46, further comprising the steps of:

exposing the coating to alkaline conditions;

releasing at least one of the film-forming compound and the first corrosion inhibitor upon sufficient degradation of one of the first degradable material and the second degradable material; and

adsorbing one or more of the film-forming compound and the first corrosion inhibitor on a surface of the metal substrate to provide an anti-corrosion barrier.

48. The corrosion inhibiting composition of claim 1, wherein the corrosion inhibitor comprises from about 10% to about 40%, by weight, of the second plurality of carriers.

49. The corrosion inhibiting composition of claim 48, wherein the corrosion inhibitor comprises from about 15% to about 35%, by weight, of the second plurality of carriers.

50. The coating of claim 38, wherein the first plurality of carriers and the second plurality of carriers comprise from about 0.1% to about 30%, by weight, of the coating.

51. The coating of claim 50, wherein the first plurality of carriers and the second plurality of carriers comprise from about 0.5% to about 10%, by weight, of the coating.

52. The coating of claim 38 having a thickness of about 25 μm or less.

53. The coating of claim 38 having a thickness of up to about 100 μm.

54. A method for inhibiting corrosion on a metal substrate, the method comprising:

applying a coating to a metal substrate, the coating comprising,

a coating base comprising an organic layer; and

a corrosion inhibiting composition dispersed in the coating base, the corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film forming compound, the first carrier body encapsulating the film forming compound, wherein the first carrier body is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, wherein the second carrier body is formed of a second degradable material, and wherein the first plurality of carriers and the second plurality of carriers have different average outer diameters.

55. A method for inhibiting corrosion on a metal substrate, the method comprising:

applying a coating to a metal substrate, the coating comprising,

a coating base comprising an organic layer; and

a corrosion inhibiting composition dispersed in the coating base, the corrosion inhibiting composition comprising:

a first plurality carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body is formed of a first degradable material;

a second plurality of carriers, each comprising a second carrier body and a first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, the first corrosion inhibitor comprising a first organic compound including a ring structure, wherein the second carrier body is formed of a second degradable material; and

a third plurality of carriers, each comprising a third carrier body and a second corrosion inhibitor, the third carrier body encapsulating the second corrosion inhibitor, the second corrosion inhibitor comprising a second organic compound including a ring structure, wherein the second corrosion inhibitor is different from the first corrosion inhibitor, and wherein the third carrier body is formed of a third degradable material.

56. A corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body has a first average outer diameter and is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and a corrosion inhibitor, the second carrier body encapsulating the corrosion inhibitor, wherein the second carrier body is formed of a second degradable material and has an average outer diameter that is larger than the first average outer diameter.

57. The corrosion inhibiting composition of claim 56, wherein the film-forming compound has a first average diameter from about 3 microns to about 15 microns.

58. The corrosion inhibiting composition of claim 57, wherein the film-forming compound has a first average diameter from about 5 microns to about 10 microns.

59. The corrosion inhibiting composition of claim 58, wherein the film-forming compound has a first average diameter from about 3 microns to about 8 microns.

60. The corrosion inhibiting composition of claim 56, wherein the corrosion inhibitor has an average diameter up to about 5 microns.

61. The corrosion inhibiting composition of claim 60, wherein the corrosion inhibitor has an average diameter up to about 3 microns.

62. The corrosion inhibiting composition of claim 61, wherein the corrosion inhibitor has an average diameter from about 0.5 micron to about 2 microns.

63. A method for inhibiting corrosion on a metal substrate, the method comprising:

applying a coating to a metal substrate, the coating comprising:

a coating base comprising an organic matrix; and

a corrosion inhibiting composition dispersed in the coating base, the corrosion inhibiting composition comprising:

a first plurality of carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body has a first average outer diameter and is formed of a first degradable material; and

a second plurality of carriers, each comprising a second carrier body and a corrosion inhibitor, the second carrier body encapsulating the corrosion inhibitor, wherein the second carrier body is formed of a second degradable material and has an average outer diameter that is larger than the first average outer diameter.

64. The corrosion inhibiting composition of claim 56, wherein the film-forming compound is released upon mechanical degradation of the first degradable material.

65. The corrosion inhibiting composition of claim 56, wherein the corrosion inhibitor is released upon chemical degradation of the second degradable material.

66. The corrosion inhibiting composition of claim 65, wherein the chemical degradation occurs when the corrosion inhibitor is exposed to an alkaline environment.

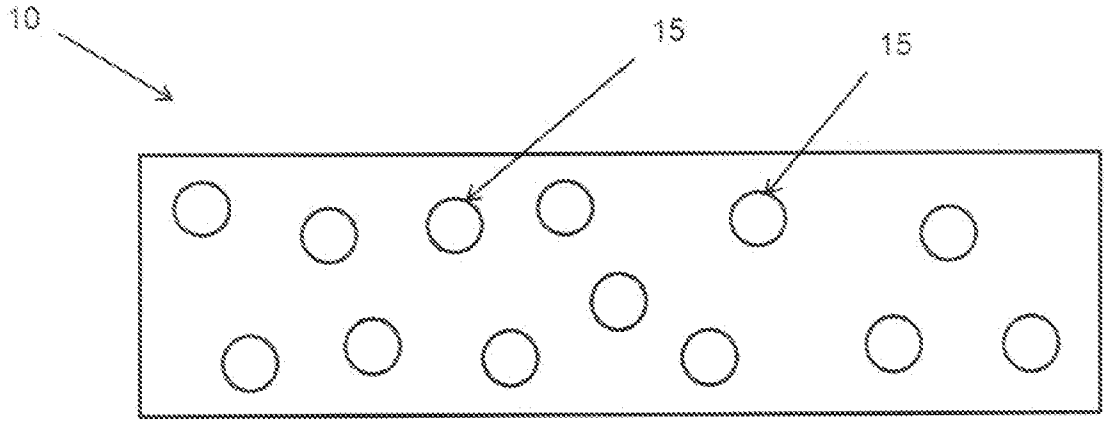


FIG. 1

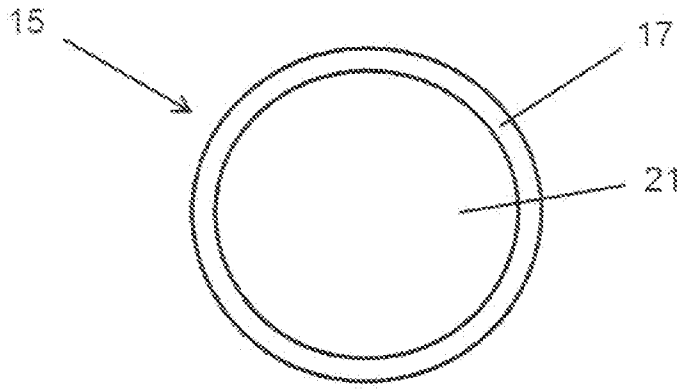


FIG. 2

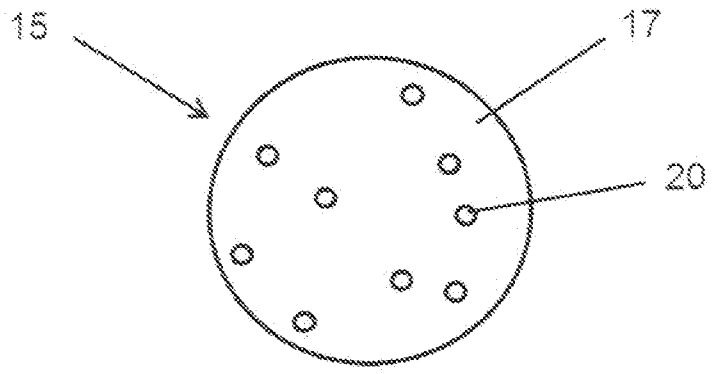


FIG. 3A

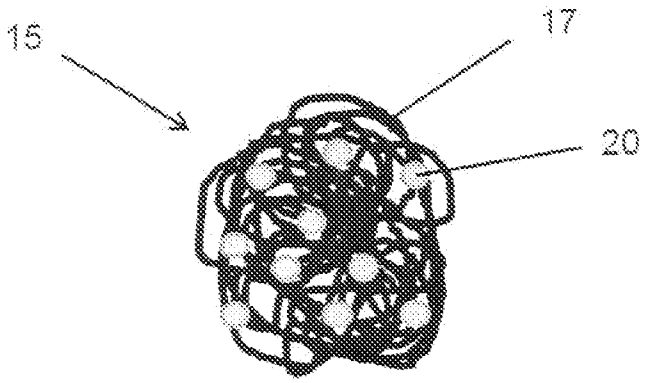


FIG. 3B

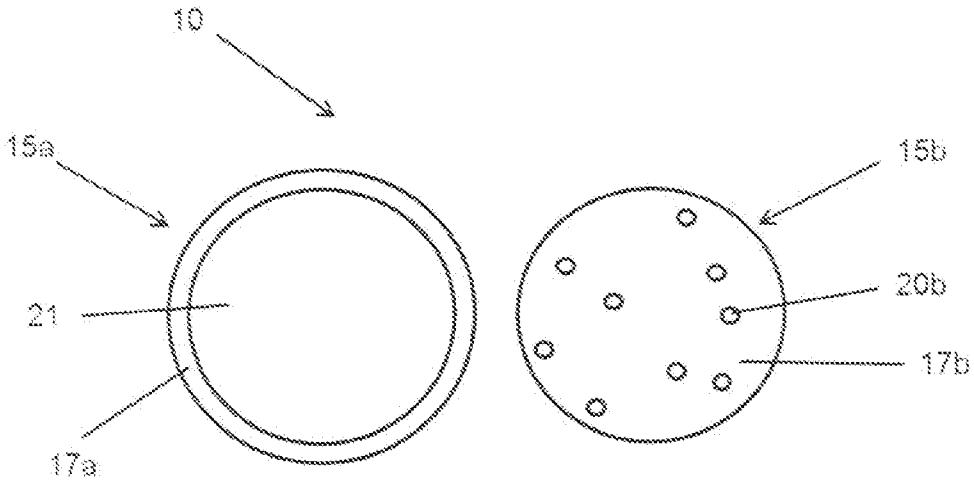


FIG. 4

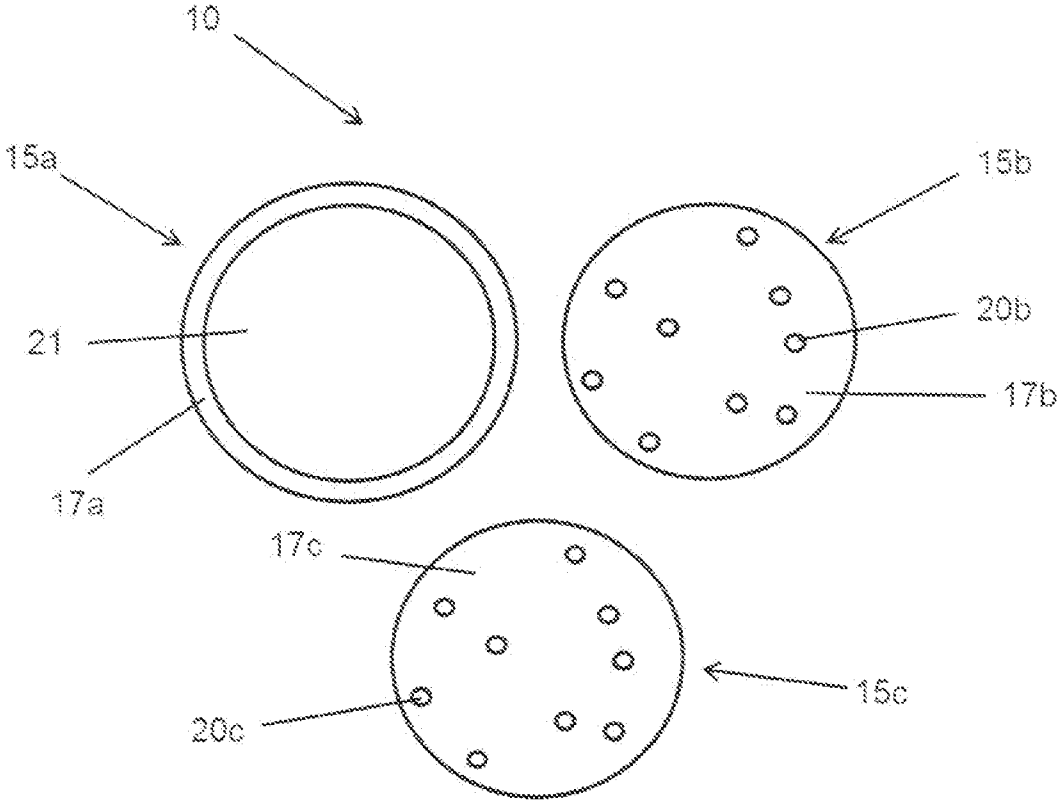


FIG. 5

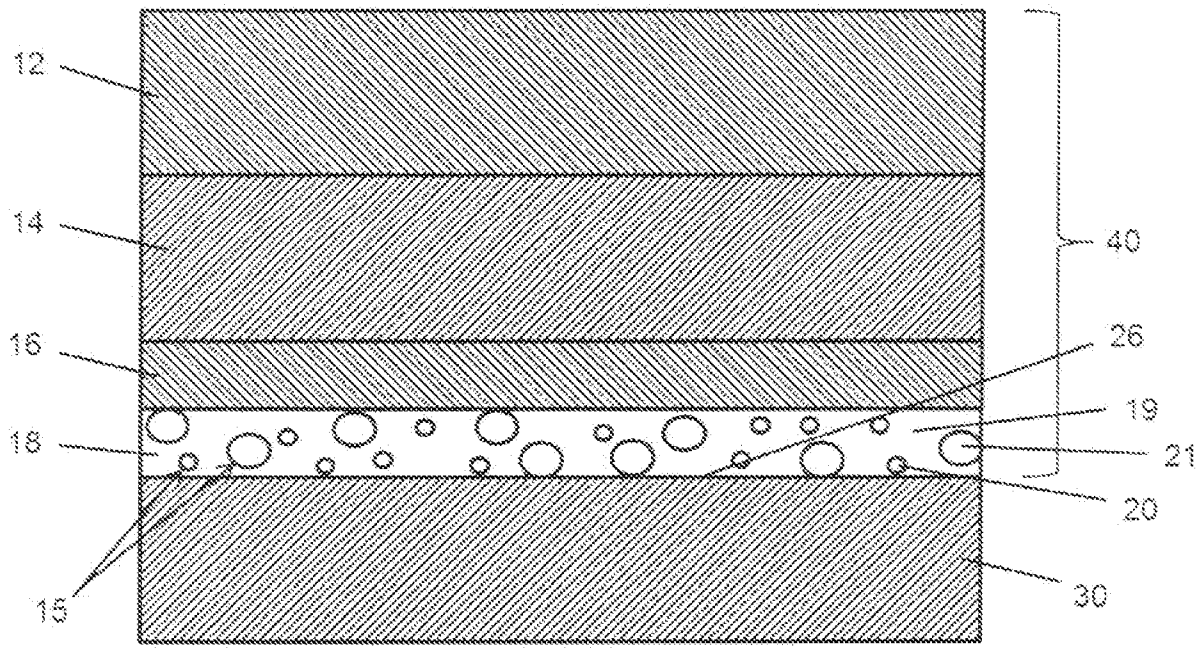


FIG. 6

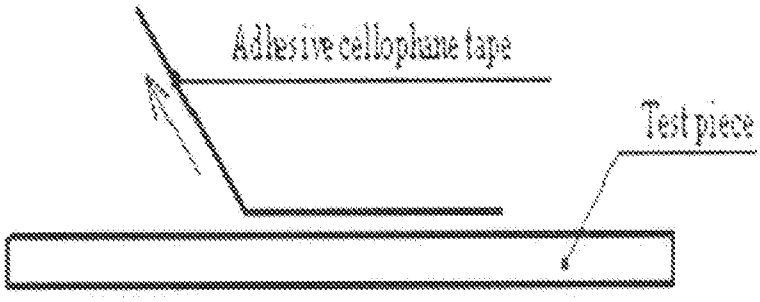


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US14/20668

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B05D 7/14; B32B 5/16; C08J 3/00 (2014.01)
USPC - 427/142, 201; 428/323
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): B05D 7/00, 7/14; B32B 5/16; C08J 3/00; C08K 9/00 (2014.01)
USPC: 427/140, 142, 154, 180, 201, 212; 428/323, 336, 402.2, 402.24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); Google Scholar; ProQuest; IP.com; encapsulating, corrosion, inhibitor, film, forming, metal, hydroxyquinoline, mercaptobenzothiazole, microcapsule

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	US 6,075,072 A (GUILBERT, CR et al.) 13 June 2000; column 3, lines 1-65; column 4, lines 43-67; column 5, lines 1-4; column 6, lines 55-60; claim 10	1-2, 8-12, 16, 28-30, 38, 42-44, 46, 52-53, 55 -- 3-7, 13-15, 17-20, 31-37, 39-41, 45, 47-51
Y	US 2013/0017612 A1 (LI, W et al.) 17 January 2013; paragraphs [0006]-[0007], [0049], [0090]	3-7, 13-15, 31-33, 41, 47-51
Y	US 2004/0079647 A1 (WARBURTON, YJ et al.) 29 April 2004; paragraphs [0004], [0043], [0092], [0095]; Table 2	17-20, 34-37, 39-40, 45

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 May 2014 (07.05.2014)	08 AUG 2014

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US14/20668

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

-***-Continued Within the Next Supplemental Box-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-20, 28-53, 55

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US14/20668

-***-Continued from Box III: Observations where unity of invention is lacking -***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-20, 28-53, 55 are directed toward methods of inhibiting corrosion and corrosion inhibiting compositions containing organic ring structures.

Group II: Claims 21-27, 54, and 56-66 are directed toward methods of inhibiting corrosion and corrosion inhibiting compositions with carriers having different average outer diameters.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical features of Group I include and a third plurality of carriers, each comprising a third carrier body and a second corrosion inhibitor; the third carrier body encapsulating the second corrosion inhibitor, the second corrosion inhibitor comprising a second organic compound including a ring structure; wherein the second corrosion inhibitor is different from the first corrosion inhibitor, and wherein the third carrier body is formed of a third degradable material, which are not present in Group II; the special technical features of Group II include a first carrier body encapsulating a film-forming compound, and a second carrier body encapsulating a corrosion inhibitor; wherein the first plurality of carriers and the second plurality of carriers have different average outer diameters; or wherein the second carrier body has an average outer diameter that is larger than the first average outer of the first carrier body, which are not present in Group I.

The common technical features of Groups I-II are a corrosion inhibiting composition comprising: a first plurality of carriers, each comprising a first carrier body and a film-forming compound, the first carrier body encapsulating the film-forming compound, wherein the first carrier body is formed of a first degradable material; and a second plurality of carriers, each comprising a second carrier body and a first corrosion inhibitor, the second carrier body encapsulating the first corrosion inhibitor, wherein the second carrier body is formed of a second degradable material and a coating for inhibiting corrosion on a metal substrate, the coating comprising: a coating base comprising an organic layer.

These common technical features are disclosed by US 6,075,072 A to Guilbert, et al. (hereinafter 'Guilbert'). Guilbert discloses a corrosion inhibiting composition (coatings suitable for metal structures including pipes, bars, rod and other related components that require protection from corrosive materials and environments; column 3, lines 1-8) comprising: a first plurality of carriers (a plurality of microcapsules containing a film forming substance; column 3, lines 9-17), each comprising a first carrier body ("microcapsule" means a miniature container comprising a frangible wall material which confines the contents of the microcapsule until subjected to a force sufficient to fracture and fragment the wall material (carrier body); column 3, lines 60-65) and a film-forming compound (a plurality of microcapsules containing a film forming substance; column 3, lines 9-17; claim 10), the first carrier body encapsulating the film-forming compound ("microcapsule" means a miniature container comprising a frangible wall material which confines the contents of the microcapsule until subjected to a force sufficient to fracture and fragment the wall material (carrier body); column 3, lines 60-65), wherein the first carrier body is formed of a first degradable material ("microcapsule" means a miniature container comprising a frangible wall material which confines the contents of the microcapsule until subjected to a force sufficient to fracture and fragment the wall material (degradable material); column 3, lines 60-65); and a second plurality of carriers (microcapsules may contain only one component, such as a corrosion inhibitor; column 3, lines 9-17), each comprising a second carrier body ("microcapsule" means a miniature container comprising a frangible wall material which confines the contents of the microcapsule until subjected to a force sufficient to fracture and fragment the wall material (carrier body); column 3, lines 60-65) and a first corrosion inhibitor (microcapsules may contain only one component, such as a corrosion inhibitor; column 3, lines 9-17; claim 10), the second carrier body encapsulating the first corrosion inhibitor ("microcapsule" means a miniature container comprising a frangible wall material which confines the contents of the microcapsule until subjected to a force sufficient to fracture and fragment the wall material (carrier body); column 3, lines 60-65), wherein the second carrier body is formed of a second degradable material ("microcapsule" means a miniature container comprising a frangible wall material which confines the contents of the microcapsule until subjected to a force sufficient to fracture and fragment the wall material (degradable material); column 3, lines 60-65) and a coating for inhibiting corrosion on a metal substrate (coatings suitable for metal structures including pipes, bars, rod and other related components that require protection from corrosive materials and environments; column 3, lines 1-8), the coating comprising: a coating base (corrosion preventing coatings of the invention comprise a film forming binder; column 3, lines 9-17) comprising an organic layer (binders useful in compositions of the invention include epoxy, polyester, polyurethane, nylon and polyvinylfluorodiene resins; latex based or water dispersed resins such as acrylic, epoxy or alkyd resins and solvent-based vehicle systems such as alkyd polymer resins (organic layer); column 4, lines 43-47).

Since the common technical features are previously disclosed by Guilbert, these common features are not special and so Groups I-II lack unity.