ECOFRIENDLY CORROSION INHIBITING ADDITIVES FOR TOMORROWS COATINGS

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Abstract

Until recently, heavy metal-based corrosion inhibitors were widely accepted as the only materials that could provide the corrosion protection needed in Paints & Coatings. Corrosion inhibitors provide an indispensable function to protective coatings. The performance of a coating under corrosive conditions requires that corrosion inhibitors provide sustainable protection during the coatings warranty. The coating industry, however, is challenged to be more cognizant of the impact toxic metals have on human health and the environment. In response to the European Directive 1999/45/EC Advancement of Technical Progress (ATP) amendment 29 effective October 2005, products containing zinc oxide and zinc phosphate required hazardous labeling due to their marine toxicity. The growing pressure to replace zinc, barium, strontium, and other heavy metals has shifted the coatings pendulum to more eco-friendly alternatives. This paper captures specific products reflecting the new paradigm of technologies based on heavy-metal free inorganic pigments as well as non-toxic organic corrosion inhibitors.

Introduction

The economic cost of corrosion throughout the world is enormous. A study jointly conducted by the Battelle Columbus Laboratories and the National Bureau of Standards (NBS) in 1975 showed corrosion to equal approximately 4.2% of the gross national product (GNP) for the United States (1, 2). A more recent study conducted in 1998, administered by Federal Highway Administration (FHWA) and performed by a team led by CC Technologies in collaboration with NACE International, showed that corrosion accounted for 3.1% of the GNP. Similar studies have also been conducted in other countries and have shown corrosion to account for anywhere from 1.5% in Australia (3) to 5.2% in Kuwait (4) of the countries' GNP. Although it is not possible to completely stop corrosion, it is possible to drastically reduce the corrosive process through the use of inhibitor-containing coatings. Coatings containing either chromates or lead-based anti-corrosives have long been used to drastically reduce the corrosion rates of various metals. Performance of these toxic inhibitors has been proven time and again over a variety of substrates, but due to the toxicity associated with both, their use in coatings has diminished in the past twenty years and has been replaced primarily by zinc, molybdenum, strontium, and barium based corrosion inhibitors. Being heavy metal based, these corrosion inhibitors too have come under recent scrutiny by many health authorities throughout the world, deeming them as aquatic toxins, and in fact, in some regions their use is either being limited or phased out. As a result, the arsenal of corrosion inhibitors available to a paint formulator has begun to shrink. A good understanding of the mechanisms of both non-toxic inorganic and organic corrosion inhibitors, as well as the possible synergies that exist between corrosion inhibitors, allows for the creation of high performance, non-toxic anti-corrosive coatings.

Non-Toxic Inorganic Corrosion Inhibitors

Inorganic-based corrosion inhibitors have long been used in coatings to prevent corrosion. These types of corrosion inhibitors can broadly be divided into either direct or indirect corrosion inhibitor classifications. Indirect inhibitors typically require a reaction with other raw materials in a coating (e.g. acidic groups) to form a by-product, which becomes the active corrosion inhibitor species, while a direct inhibitor is essentially active in nature and does not require a secondary reaction. The classic example of an indirect inhibitor would be red lead (Pb_3O_4), while an example of a direct inhibitor would be Zinc phosphate. The focus of this paper will be on non-toxic, direct inorganic inhibitors, which function primarily through (1) anodic and/or cathodic passivation and (2) improved barrier properties.

Inorganic Corrosion Inhibitors: How do they work?

A) Anodic and Cathodic Passivation

Inorganic inhibitors control corrosion in neutral solutions by acting as polarizing agents to slow the three elements of the corrosion process: anodic reactions, cathodic reactions, and ionic currents in the solution and the metal itself (5). These inhibitors increase the likelihood of a chemical reaction, which will result in a “passive” – protective layer on the surface of the metal. In simple terms, these inhibitors act to short-circuit the electrochemical reactions, which take place during corrosion. The anodic dissolution reaction involves a release of metal ions into solution, as well as a generation of electrons at the cathode. The anodic passivators discussed here depend on dissolved oxygen and migrate readily to the anodic sites (6). In turn, these inhibitors react to form salts which act as a protective barrier. On the contrary, cathodic reactions involve a reduction of dissolved oxygen and a consumption of electrons. Cathodic passivators impede corrosion by forming surface deposits (precipitates) at the inactive sites within a metal. These surface deposits reduce the access of oxygen to the cathode (7).

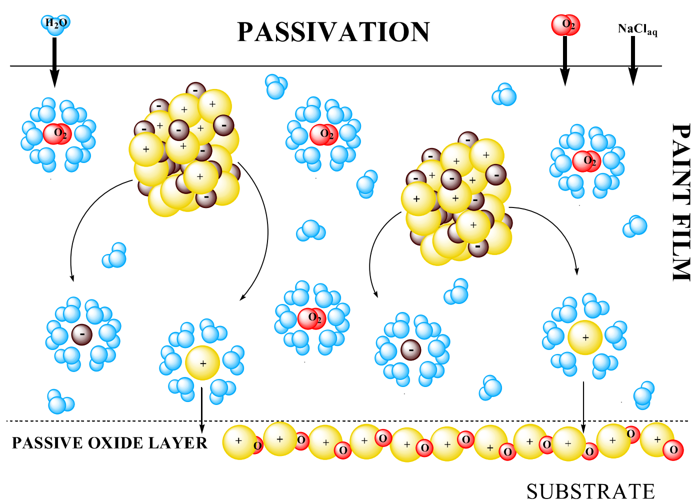

Figure 1: Schematic mechanism of a direct, non-toxic inorganic corrosion inhibitor.

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