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ANALYTICAL STUDY ON CORROSION COVERING AND ITS PROTECTION: CHEMICALLY BONDED PHOSPHATE CERAMICS

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Analytical Study on Corrosion Covering and Its Protection: Chemically Bonded Phosphate Ceramics

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Abstract – Corrosion is the surface disintegration of metals/alloys within specific environment. Some metals basically exhibit high corrosion resistance than others and this can be attributed to several factors like their chemical constituents, the nature of electrochemical reactions itself and others. The corrosion resistance of metals can be defined in terms of its ability to withstand aggressive conditions. This determines to a large extent the operational lifetime of components in service.

Keywords: Corrosion, Delamination, Surface, Metal

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INTRODUCTION

Corrosion of steel, aluminum and other structural metals erodes the safety and financial stability of industries and countries alike. Fighting corrosion in ships, tanks, planes and equipment costs the Pentagon $22.9 billion a year. Corrosion costs advanced industrialized nations about 3.5 percent of GDP to replace damaged material and components, plus a similar amount due to lost production, environmental impact, disrupted transportation, injuries and fatalities. While traditional corrosion protection has relied mostly on short-lived physically-bonded coverings of substrate surfaces, a new category of chemically bonded phosphate ceramics (CBPCs) can create a long-lived passivation layer that stops corrosion. This is further protected by a tough ceramic outer layer.

The limits of traditional corrosion protection For generations, polymer paints have acted as a physical barrier to keep corrosion promoters such as salt water and oxygen away from steel and aluminum substrates. This works until the paint is scratched, chipped, or breached and corrosion promoters enter the gap between the substrate and polymer coating. Then the coating can act like a greenhouse—trapping water, oxygen and other corrosion promoters—allowing corrosion to spread. Placing sacrificial is reactive elements next to steel that will corrode first, such as zinc and galvanized coatings, is another strategy. This works until the sacrificial elements are used up and recoating must be done, usually after a few years.

Cathodic protection, where a negative voltage is imposed on steel, can limit corrosion on pipelines or other stationary, continuous metal structures where voltage can be attached. But this can fail if it's not properly insulated and voltage goes to ground. For assets that demand long-term corrosion protection, stainless steel alloys work. But with stainless steel costing up to six times more than mild steel, this option is often cost prohibitive.

REVIEW OF LITERATURE:

The factors that affect the environment include nature, thermodynamics and the kinetic among others (Ige, 2007) but generally, corrosion resistance or chemical resistance depends on many factors. Its complete and comprehensive study requires knowledge of several fields of scientific knowledge (Fontana, 1987). Some of these factors are as listed: effects of oxygen and oxidizers, temperature, velocity, corrosive concentration, galvanic coupling, metallurgical factors, (Wang, 2009; West, 1986; Tendayi, 2010). Materials selection is a powerful tool for dealing with severe corrosion. Failures occurring as a result of corrosion attack can be very expensive therefore preventing or reducing these attacks becomes very significant to the industry and households (Fontana, 1987). The materials engineer's solution to the fatal failure induced by corrosion is simply the fabrication of anticorrosion coatings with superior chemical and mechanical properties than the parent material. The improvement of the lifespan and performance of metallic alloys and components through application of numerous anti-corrosion coatings is highly advantageous (Popoola et al., 2012). These coatings enable more efficient metals/components, efficient industrial operations, cost reduction, saving of scarce material resources and reduction in pollutant emissions. Anticorrosion coatings often involve development of new surface materials which can impart numerous functional properties unto the surfaces of metals/components. New materials include composites, nano-composites, nano-particles. Numerous industries make use of anticorrosion coatings since almost all engineering materials (composite, alloys, metals, polymers and ceramics) can be used as reinforcement coating on materials surfaces.

Side bar: On the job with A&K Painting When Andy Robbins, CEO of A&K Painting, a Charlotte, N.C.-based industrial and commercial paint contractor that does work in five states, first heard about the new EonCoat ceramic coating at a conference, the concept intrigued him. "The environmental guidelines of the last decade are rapidly becoming standards," said Robbins. "Since environmental codes are tightening for new builds, remodels and existing facilities, reducing or eliminating VOCs in paint has been a growing concern for us and our customers." Robbins stayed in touch with the ceramic coatings' developer, Wilson, N.C.-based EonCoat LLC, ultimately visiting the plant, participating in testing and providing R&D feedback.

"For industrial and commercial customers looking to limit VOCs and HAPs to meet stricter regulations, EonCoat is a proactive way to do so," said Robbins. "There are no fumes. Contractors could literally spray within 10 feet of someone working in an occupied space with no concern for odor or getting residue on carpet, computers or office furniture." Since a true ceramic shell covers the corrosion barrier, EonCoat resists water, fire, abrasion, chemicals, corrosion and temperatures up to 1,250° F. It protects against high-pressure power washing and steam cleaning able to withstand water pressure of 4,500 psi/310 bar and steam at over 380° F/193° C. EonCoat also has a flame spread rating of zero, which means that flame can be directly exposed to its coated surface and it will not catch fire unless enough heat is generated to make the substrate behind the coating self-ignite and the ceramic coating does not release any fumes when exposed to fire [Del Williams, 2011].

APPROACH TO CORROSION PROTECTION:

A new approach to corrosion protection ideally, engineers, facility managers and industrial paint contractors would want the long-term corrosion-resistance of a stainless steel part with the lower cost of coating application. A new category of CBPCs such as EonCoat, for instance, is now basically making this possible. "Unlike polymer paints that simply cover a substrate, CBPCs essentially 'alloy' the surface," said Tony Collins, CEO of EonCoat LLC, Wilson, N.C. "When a dual-component spray gun mixes an acid phosphate with base minerals and metal oxides in a water slurry, a chemical reaction occurs on the surface of the steel substrate," said Dr. Arun Wagh, a former materials engineer at Argonne National Lab, and lead developer of the technologies underlying EonCoat ceramics. "A hand-held thermometer indicates a 10-12° F temperature rise, as iron becomes a corrosion-resistant passivation layer of iron oxy hydroxide. Because the passivation layer is electrochemically stable, like gold and platinum, it does not react with corrosion promoters such as water and oxygen." [Del Williams, 2011]

Scanning electron microscopy indicates this passivation layer is about 20 microns thick. X-ray diffraction indicates this passivation layer is about 60 percent iron with components of phosphate, magnesium, silicon, hydrogen and oxygen.

"History suggests that EonCoat's passivation layer may resist corrosion indefinitely, as demonstrated by the Iron Pillar of Delhi," said Wagh. "The Iron Pillar, a seven-meter high, six-ton Indian artifact that has resisted corrosion for 1,600 years with its original inscriptions still legible, has a virtually identical passivation layer to that of EonCoat." In contrast to typical paint polymer coatings which are sit on top of the substrate, EonCoat bonds through a chemical reaction with the substrate, so slight surface oxidation actually improves the reaction. This makes it virtually impossible for corrosion promoters like oxygen and humidity to get behind the coating the way they can with ordinary paints [Del Williams, 2011].

The corrosion-resistant passivation layer is further protected by a true ceramic outer shell. This dense ceramic outer shell is impermeable to water, and resists impact, abrasion, chemicals and fire. The ceramic outer shell forms simultaneously with the passivation layer and chemically bonds with it, after acid and base materials mix in the spray gun nozzle then react with the substrate surface. The dual-layer ceramic coating can be used both as a primer and a topcoat, and can be applied in a single pass that's dry to the touch in a minute, hard dry in 15 minutes and can be returned to service in an hour.

Though CBPCs such as EonCoat have proven themselves in the laboratory and in examples such as the Iron Pillar, the effectiveness of the new material had to be compared to that of traditional anti-corrosion coatings.

Duplicating a NASA corrosion test, EonCoat was put to the test against 19 leading anti-corrosion coatings in a live corrosion test, viewable to the public by webcam. Coated samples were scribed, and then exposed to 12 hours of sea spray, followed by 12 hours of sunlight (or the UV light equivalent). After 45 days, every other high performance coating tested failed. Except for the rust on its scribe (gouge) line, the EonCoat sample looked the same as day one.

To monitor another ongoing corrosion test modeled on NASA's sea spray test, the public can view, zoom and control a live webcam at www.eoncoat.com. In the latest test, which has passed 120 days and includes brand names matched to numbers, 20 Q panels coated with a popular primer, topcoat or EonCoat are sprayed daily with corrosive seawater.

"There's nothing like seeing results with your own eyes," said Collins of the ongoing corrosion tests displayed by webcam. "The product has gone more than 10,000 hours with no corrosion in a salt spray ASTM B117 test, but we believe that engineers, facility managers, and industrial contractors will see value in comparing its effectiveness with leading brands. CBPCs like EonCoat are a new approach to corrosion protection that should be looked into as aging plants, equipment and infrastructure need to be safely maintained as long as possible. [Del Williams, 2011]"

The anti-fire, anti-water, anti-abrasion and anti-corrosion:

"The anti-fire, anti-water, anti-abrasion and anti-corrosion benefits of the new protective ceramic coating make it a promising product to use for a host of applications from extending the service life of tanks, machinery, steam pipes and cement floors to serving as a slimmer, less costly alternative to existing bulky firewalls," said Robbins. The ceramic coating typically costs less than the high-temperature paints or specialized epoxies it replaces, and paint contractor labor can also be cut in half. The ceramic coating has an ability to bond directly to most substrates and because it dries within seconds of exiting the spray nozzle, high build coatings in one coat are possible.

Another plus for facility managers is how the protective ceramic coating can be applied on hot or cold surfaces from 35° F to 200° F, which makes it suitable for all-weather indoor, outdoor application. Because the ceramic coating can readily blend with dozens of additives, it can be used to create custom textured finishes like high-end stucco, sand plaster, and even spray-applied "tile". Since the coating is unaffected by UV, it resists fading when exposed to sunlight. For extra safety in facility or commercial settings, adding granite to the ceramic coating can also make for durable non-skid flooring. "Unlike multi-colored latex coating systems on the market, EonCoat can mix with special materials to give color and texture to high traffic areas that must withstand abuse such as corridors, entry ways, or accent walls in offices, healthcare and childcare facilities," said Robbins [Del Williams, 2011].

CONCLUSION:

Corrosion is necessary in the industry because the penalties of failures due to corrosion can be very costly including safety hazards. Material loss and component failures can be prevented with proper selection of coatings/Materials in most manufacturing industries. Adequate knowledge of these processes is therefore inevitable. Anti-corrosive coatings produced new materials surfaces with numerous functional properties and unique features.

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