2013

"Recent Advances at NEI on Self-healing, Chromate-free Conversion Coating for Magnesium Alloys"

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Paints and coatings applied to the surface of magnesium parts can slow the rate of corrosion and maintain structural integrity and appearance. Over the years, the most widely used paints and coatings for magnesium alloys have contained hexavalent chromium, also known as hex chrome or chromate. In recent years, the use of chromate has been drastically curtailed because of its carcinogenic nature and harm to the environment. A chromate coating has the special ability to "self-heal," i.e., repair itself if scratched or damaged, thereby providing active corrosion protection of the underlying metal.

The first coating layer in direct contact with the metal surface, applied prior to paint (primer and topcoat), is called a pretreatment. Many pretreatments are thin conversion coatings, a few tenths to several micrometers thick that form by chemical reaction of a liquid formulation with the outermost layers of the solid metal surface.

For over 75 years, the best performing and most reliable conversion coatings have been made with chromate. Chromate conversion coatings (CCCs) are self-healing and provide excellent adhesion with overlying paint. Although chromate-free conversion coatings are available, the corrosion resistance offered by them, in absence of the ability to self-heal, does not match that of the CCC.

At NEI, we have developed a breakthrough chromate-free conversion coating for magnesium alloys that independently provides exceptional corrosion resistance while also improving adhesion with an overlying paint layer (primer). Additionally, this coating is able to self-heal. The NEI conversion coating, NANOMYTE® PT-60, performs as well as or better than a conventional CCC in terms of protection against corrosion. Results also show performance approaching that of a state-of-the-art anodized coating, which is another well-established, but more expensive, technology to protect magnesium alloys.

For long term corrosion protection, a multilayer paint and coating system consisting of pretreatment, primer and topcoat is used. The paint principally acts as a barrier layer against corrosion. One of the key factors that determine the performance of the paint and coating system is the adhesion of the paint layer to the alloy substrate. The surface chemistry of the conversion coating has to be tailored for primer compatibility based on the desired application.

In order to address the corrosion protection needs of different industries including military, aerospace, automotive and mobile computing, Mg AZ91D panels (both untreated and pretreated with CCC and PT-60) were coated with selected primers. **Figure 1** compares the performance of panels coated with two military specified primers after 500 hours of exposure in the salt spray environment following the ASTM B117 standard protocol.

A conventional two component, lead and chromate free, epoxy primer was used to meet the MIL – DTL - 53022D - Type I (white), specification. The primer can be used under MIL – PRF - 85285D (non-aircraft) polyurethane topcoats, or polyurethane chemical agent resistant coatings (CARC) specified in MIL-DTL-53039B Type 1, MIL-DTL- 64159 or MIL-PRF-22750F epoxy topcoats.

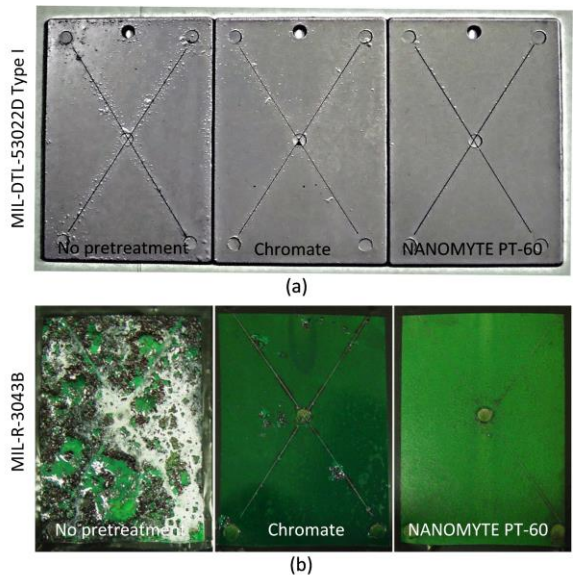


Figure 1: Unprotected Mg AZ91D 4" X 6" panels, and coated with chromate conversion coating and NEI's PT-60 - after 500 hours of salt-fog exposure. Panels were coated (and then scribed) with (a) Military Specified MIL-DTL-53022D primer Type I, (b) MIL-R-3043B resin.

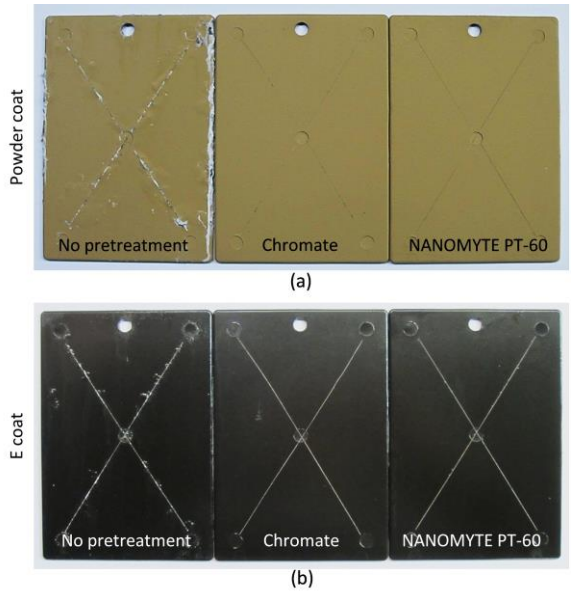


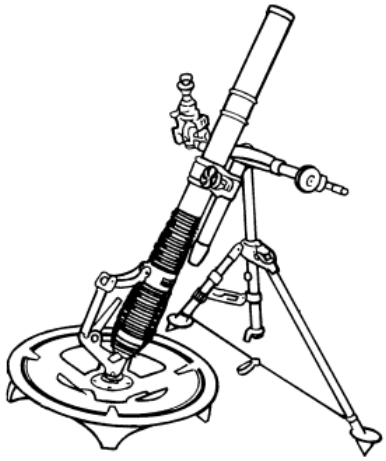
Figure 2: Unprotected Mg AZ91D 4" X 6" panels, and coated with chromate conversion coating and NEI's PT-60 - after 500 hours of salt-fog exposure. Panels were coated (and then scribed) with (a) Powder coat and (b) E-coat.

On the other hand, the MIL-R-3043B (green) is a thermosetting resin coating, designed as a permanent corrosion preventive, oil resistant coating for metallic surfaces of engine parts and other aircraft components.

In addition to the conventional liquid primers, powdered plastic resin (powder coat) and electrodeposited (e-coat) primer was also applied on the conversion coatings to measure the corrosion resistance of the coating system. **Figure 2** compares the performance of panels coated with powder coated (tan) and e-coated (black epoxy) primers after 500 hours of exposure in the salt spray environment following the ASTM B117 standard protocol.

It is evident that the buildup of corrosion products in the scribe is greatest for the Mg AZ91D panels without any pretreatment. CCC resulted in reduced corrosion on the primed panel while further reduction in corrosion and blistering was obtained in the case of PT-60.

Recently, NEI has worked with the U.S. Army Armament Research Development and Engineering Center (ARDEC) at Picatinny Arsenal, NJ to successfully demonstrate the effectiveness of PT-60. NEI coated two magnesium base plates for a M224 60 mm light mortar application. The prototypes were made at Picatinny Arsenal, cut from the alloy Mg WE43. This was the first time PT-60 was applied on this alloy (**Figure 3**). Following the PT-60 treatment, an epoxy e-coat and then a powder coat were put on for prototype feasibility purposes (**Figure 4**). This effort addresses the need for the development of chromate-free coating systems for lightweight alloys to be used in weapon systems for the warfighter.



(a)

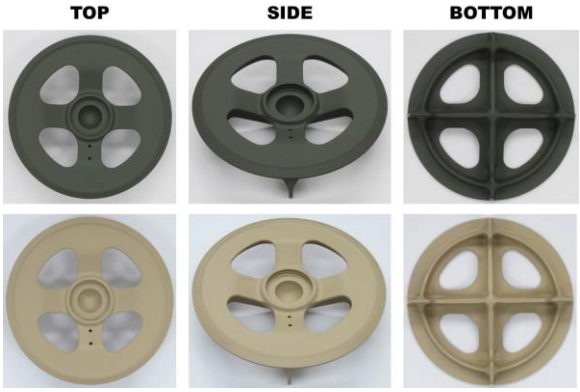
(b)

Figure 3: (a) Schematic of a M224 60mm mortar [http://www.inetres.com/gp/military/infantry/mortar/M224.html] (b) Top view of the Mg alloy WE43 mortar base plate (12" diameter) where PT-60 pretreatment was applied after thorough cleaning.

NANOMYTE® PT-60, a patent pending coating formulation, is a commercial product and is sold as a liquid in 1 to 5 gallon pails or 55 gallon drums. Recently Elsevier's Metal Finishing magazine published an article featuring this technology in the May 2012 edition: http://digitaleditions.sheridan.com/publication/?i=110789&p=34

Analogous environmentally friendly, self-healing conversion coatings have been developed for other metal alloys including aluminum, zinc plated and galvanized steel.

(a)



(b)

Figure 4: Subsequent to the PT-60 conversion coating, the Mg base plates were coated with (a) a military specified primer using e-coat. (b) Finally these base plates were coated with a military specified powder coat in green and tan.

About NEI Corporation

Founded in 1997, NEI Corporation develops, manufactures, and distributes nanoscale materials for a broad range of industrial customers around the world. NEI's products incorporate proprietary nanotechnology and advanced materials science to create significant performance improvements in manufactured goods.

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