Automotive Corrosion Symposium

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Using Computational Corrosion Analysis to Deploy Corrosion Prevention & Control in Automotive Design

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Development of a Computational Framework for Prediction of Galvanic Corrosion for Automotive Applications

L. Saberi and M. Amiri • George Mason University

The Mitigation of Galvanic Corrosion between Mechanically Coupled Aluminum and Carbon-Fiber Reinforced Polymer Matrix Composites

Raghu Srinivasan[a] and Lloyd Hihara[b]

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Expanded Cure Capabilities of Electrocoat to Resolve EV Challenges

David Stone • PPG

Keynote Address

Automotive Corrosion Prevention and Assessment – Moving Toward Virtual

Michael Ostermiller* • GM

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Shorter vehicle development cycles and the high costs of prototype hardware have increased the call for more "virtual" corrosion assessment and prevention work. But what options do we really have? We'll look at where we have been when it comes to corrosion avoidance work, where we are today, and where we need to be if we are going to "go virtual".

Vehicle corrosion avoidance is complex and ultimate performance can be influenced by a multitude of variables. One pathway is "ultimate performance simulation" or predicted real world performance given variable inputs (design, materials, processing, degradation rates, customer use and care, environmental inputs, etc.). However, understanding all the potential variables or even ranking them in order of importance can be a challenge. Another pathway is to build in robust knowledge "AI" during the design development process. Ultimately, a combination of both will likely evolve – better upfront knowledge and tools and quicker more accurate simulations of chosen variables deemed most critical to "bookend" performance and drive decisions.

Keynote Address

Challenges to Prevent Corrosion Issues in Mixed-Material Vehicle Structures

Alan I. Taub • University of Michigan

The potential for reducing weight in transportation vehicles using high-strength steel, aluminum, titanium and magnesium alloys and polymer composites is well established. As the industry has moved to greater use of these materials, there is a need to devise mixed-material joining methods the are robust in both mechanical and corrosion performance. Key is to achieve high durability galvanic isolation between the different materials which are often produced in different forms such as sheet, extrusions and castings. Developing and validating the approaches is made more challenging by the continued reduction in product development time and limited ability to perform full corrosion tests on prototype vehicles. This points to the need for not only faster accelerated corrosion tests but also for advanced modeling capability. The latter is becoming possible through co-development of the material, the component design and manufacturing process, including joining, using state-of-the-art Integrated Computational Materials Engineering (ICME) models.

Electrocoat Challenges for Battery Electric Vehicles

Joshua Abbott • Axalta Coating Systems

Production of BEVs at greenfield and brownfield plants places new challenges on the E-coat line. The increased complexity of the body reinforcement needed to support the battery weight and the increased use of mixed metal substrates means that the E-coat product must offer a broader bake window to ensure cure and compatibility with a range of substrates and pretreatments. This enhanced capability required of the E-coat product all takes place under the increasing demands for sustainability improvements in the paint shop.

To meet these new challenges, Axalta has developed AquaEC™ Flex. We will review the key attributes of this new E-coat: (1) broad bake capability with cure at lower temperatures; (2) ultra-high throw power to ensure coverage of complex interiors while maintaining a low overall usage; and (3) capability for superior anti-corrosion performance including edge protection. In addition, this paper will highlight the robust on-line performance of EC Flex (resistance to phosphate and other contaminates and low mapping sensitivity) within the context of improved sustainability from reduced water usage and energy consumption.

Use of Laboratory Accelerated Cyclic Corrosion Test (CETP-00.00. L-467) for Predicting On-Road Corrosion Behavior of AA6xxx Coupled to Carbon Fiber Reinforced Plastics

Priyanka Adapala • The Ohio State University

Structures made from a combination of aluminum alloy (AA) and carbon fiber reinforced plastic (CFRP) are susceptible to galvanic corrosion of the AA in harsh atmospheric conditions, such as might exist for closure panels in automotive applications. It is important to understand the galvanic corrosion behavior of these materials under laboratory conditions as that might allow prediction of performance in real environments. This work tested specially designed AA6xxx-CFRP coupons, including AA6111 and AA6022, connected to CFRP made from two different carbon fiber fabrics (twill and random) with the aim of comparing the corrosion behavior in a laboratory cyclic exposure chamber (CETP-00.00. L-467) to on-road exposure. The extent of corrosion was assessed by galvanic current measurements, optical profilometry (OP), cross-sectional area analysis and microscopic analysis. Based on the results, it was determined that exposure in the environmental chamber was successful in simulating the corrosion modes that occurred during 1 year of on-road exposure.

Exploring New Methods of Corrosion Assessment for Multifunctional Coatings Based on Deterministic-Probabilistic Modeling for Automotive Applications

Homero Castaneda • Texas A&M University

Automotive industry is leading to lightweight, sustainable and electrical technologies. This trend will affect the design and characteristics of each automobile due to the more demanding conditions. Vehicles face harsh environment and extreme conditions requiring not only materials with excellent mechanical properties but also corrosion resistance properties. Today, it can be assured that corrosion protection of almost all automobile bodywork includes a multilayer coating system. New trends for corrosion and durability testing are leading to simulation of more realistic conditions of the automobile parts exposed to daily conditions. Experimental testing has been the main criteria for the automotive industry for quality control and assurance. New theoretical tools have been developed for materials characterization to characterize, quantify or complement laboratory testing in shorter times. In this presentation we cover different coating multilayer system by using a combination of experimental and theoretical approach for studying the overall corrosion assessment on coatings based on multidimensional damage evolution model when the coating/substrate system is exposed to cyclic aggressive environment. Steady state conditions are assumed in this model and deterministic approach is considered in the system comprising different layers, and metallic substrate. The theoretical tool of deterministic-probabilistic modeling has been employed for the search of critical performance parameters. The deterministic–probabilistic approach based on charge current distribution and corrosion assessment has been developed to represent the durability, and physicochemical properties inherent to the coatings and the environmental and material characteristics have been fully accounted for the high resolution local electrochemical techniques and classic EIS experimental testing methods. In this work, the experimental mechanistic analysis and the use of high-resolution equipment can be validated by theoretical computer tools.

Understanding the Effect of Anodic Polarization on SCC Resistance of Automotive AA6111-T8 to Simulate Coupling with CFRP

Katrina E. Catledge and Jennifer S. (Warner) Locke • The Ohio State University

The strength-to-weight ratio and stress corrosion cracking (SCC) resistance of 6xxx Al-Mg-Si alloys makes them attractive for automotive applications in conjunction with steels and carbon fiber reinforced polymer (CFRP). However, the SCC resistance of AA6xxx alloys has undergone limited assessment, none of which covers anodic polarization conditions that will result from galvanic coupling in automotive applications. As such, this research investigates the effects of anodic polarization on the SCC resistance of AA6111-T8 in terms of threshold stress intensity (KISCC) and Stage II crack growth rates (da/dtII).

Experiments in 0.6 M NaCl show that applied anodic polarization reduces SCC resistance by decreasing KISCC and increasing da/dtII. At open circuit potential (OCP), average KISCC is measured as 16.3 MPa√m, while anodic polarization to 100 mV above OCP reduced KISCC to less than 7.5 MPa√m.

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Verification of Mixed Metal Corrosion Modeling Approaches

James F. Dante • Southwest Research Institute

Electrochemical modeling of mixed metal corrosion has seen increased use over the last decade as a potential means to rapidly assess both corrosion risk during system design and mitigation of risk resulting from surface treatments. Used as a screening tool, material selection or surface treatment selection can be effectively down selected prior to performing accelerated laboratory or extended outdoor exposure testing. While differing FEA modeling software can be used to predict electrochemical potential distribution and current flow, all require the use electrochemical polarization data to define boundary conditions for the electrochemical parameters. In this presentation, we directly compare model predictions of galvanic corrosion for a stainless steel/aluminum couple exposed to either immersion or 90% Relative Humidity (RH) conditions. These predictions are then compared with a direct measure of corrosion currents using a coupled Multi-Electrode Array (MEA) technique. While reasonable agreement between predicted and measured galvanic corrosion currents is found, some important findings point forward to considerations needed in order to improve modeling approaches.

Corrosion Model of a Zinc-Iron Couple using Rotating Disc Electrode Electrochemical Parameters to Simulate Automotive Environmental Conditions

Javier Esquivel, Niamh Hosking, and Mark Nichols • Ford Motor Company

The environmental and road conditions in which vehicles operate can lead to metallic corrosion, and therefore robust corrosion protection of the vehicle body structure, chassis, and powertrain systems is required to ensure a useful vehicle service life. There are many forms of corrosion that may develop within the systems that make up the vehicle. Lengthy vehicle corrosion tests are conducted by the manufacturers to confirm that their vehicle designs, materials, and processes will meet the customer expectations and regulatory requirements for corrosion resistance. Unlike most other vehicle attributes today, there are no numerical tools that can assist the vehicle design engineer in simulating or predicting corrosion performance of the vehicle in service. There are several reasons for the lack of computer aided engineering (CAE) in vehicle corrosion assessments, chiefly the complex nature of the corroding vehicle-in-service system. Nonetheless, there is a strong desire to develop CAE tools to augment, and eventually replace, or partially replace, the physical testing currently used as the primary method for corrosion assessments.

In this work, an initial effort to simulate galvanic corrosion of a Zn-Fe couple in the uncoated condition and under varying electrolyte film thicknesses (δ) is presented. A model to predict the galvanic current densities was constructed in the corrosion module within COMSOL Multiphysics® using the 'secondary current distribution, shell' function on a Zn-Fe metal-to-metal interface of equal areas. The corrosion kinetics used by the model were determined experimentally and used as input parameters. Electrochemical potentiodynamic polarization curves were obtained for each metal in 0.5 wt. % NaCl solution, using a Rotating Disc Electrode (RDE). The anodic and cathodic kinetics of the materials were obtained over a range of RDE rotating speeds. Each rotating speed corresponded to a specific diffusive layer thickness, which was assumed to approximate δ. A linear relationship between the limiting current density for oxygen reduction reaction (n=4) as a function of δ was obtained from Levich plots. Utilizing these parameters, the model showed that anodic current density on the Zn surface increased with decreasing electrolyte thickness. The amount of corrosion predicted by the simulation was compared to galvanic current measurements of a Zn-Fe test coupon in a controlled environment. The current model lays the foundation to simulate the dynamic changes in relative humidity, temperature and, thereby, electrolyte film thickness and resulting corrosion rates for these metals in standard automotive cyclic corrosion tests.

In Situ Quantitative Measurement of Corrosion on the Nanoscale by Quantitative Phase Microscopy (QPM)

Ebenezer O. Fanijo[a], Joseph G. Thomas[a], Yizheng Zhu[a], Javier Esquivel Guerrero[b], Niamh C. Hosking[b], F. Marc Michel[a], and Alexander S. Brand[a]

[a]Virginia Polytechnic Institute and State University • [b]Ford Motor Company

The measurement of nanoscale surface topography evolution correlated with electrochemical properties in an aluminum alloy is critical to understanding the corrosion initiation (which is mainly governed by dynamic processes that occur at the nanometer levels), microstructure-corrosion relationship, and, eventually, controlling or modifying these corrosion behaviors. This work presents a novel Quantitative Phase Microscopy (QPM) technique, Spectral Modulation Interferometry (SMI), to study in situ corrosion of an aluminum alloy at the nanoscale in real time. SMI offers high sensitivity, rapid image acquisition, and speckle-free images; thus, real-time quantification of surface topography evolution during corrosion can be obtained accurately to evaluate the temporally- and spatially-dependent corrosion rates. With a novel 3D-printed fluid cell, both in situ nanoscopic corrosion (by SMI) and electrochemical activity (via resistance response) can be measured simultaneously in flowing conditions. Therefore, this method can be categorized as another surface characterization technique for evaluating corrosion initiation and morphology in aluminum alloys, the interpretation of corrosion propagation, and the subsequent development of corrosion resistance for the alloys.

Measurement of Environmental Parameters and Corrosivity for Monitoring Outdoor Exposure Sites and Laboratory Corrosion Tests

Fritz J Friedersdorf • Luna Labs USA, LLC

Atmospheric corrosion is a concern for asset service life in severe environments. Laboratory tests, outdoor exposures, and on-vehicle testing are used to characterize performance of automotive materials and estimate service life. The classification of environmental severity and control of laboratory tests are dependent on environmental parameters of temperature, relative humidity, contaminant chemistry, and deposition rates. Besides environmental parameters, environmental severity may also be measured using mass loss coupons. These coupons may be used to classify severity of an outdoor exposure site or determine the consistency of a cyclic corrosion test. Although the importance of time varying environmental conditions to material degradation are well recognized, severity classification and mass loss are long-term monthly or annual average measurements that provide little information on the instantaneous conditions that determine corrosion rate. Measurements of time variant parameters are important for accurate and repeatable laboratory testing and can be used to improve our understanding of material response in-service.

Environmental and, recently standardized, electrochemical measurements can be used to obtain data at short time intervals (5 – 30 minutes) throughout a laboratory or outdoor test. Testing at multiple laboratories has been performed and differences in the temperature and humidity profiles within a single test, between tests, and between laboratories has been noted for a common automotive test cycle. These differences in chamber conditions affect the coating performance and corrosion measurements made using electrochemical sensors and test panels. Similar measurements have been made at an outdoor marine site. Measurements of the environment conditions at the exposure rack are compared to local weather station data. Daily temperature is higher and surface relative humidity lower for materials under test as compared to local weather station data. The surface relative humidity, electrolyte conductance, and corrosion rate are related parameters that can be used to characterize the conditions that promote corrosion. Monthly wet candle and wind speed and direction, and hourly precipitation are compared to electrolyte conductance and corrosion rate measurements. These time-based measurements of environment are used to compare laboratory tests conditions to natural environments, with the intent to improve materials testing.

Crevice Corrosion of Aluminum Enclosures at Sealing Interfaces

Ullrich Haus • General Motors

Electronic components in wet areas of the vehicle are commonly housed inside watertight Aluminum enclosures. Those enclosures need to stay watertight over the life of the vehicle. Common housing assemblies usually pass the initial water ingress test, but it was shown in cyclic corrosion lab tests that crevice corrosion at the Aluminum seal interface can penetrate pass the seal and cause premature leaks over time. The presentation shows the impact of seal design, material choices and coatings on crevice corrosion and what improvements can be introduced to mitigate it.

The Complex Synergy of Delayed Cracking Failures in Transmission Gear Assemblies

Joshua James • Edison Welding Institute

Often material failures involve a synergy of mechanisms, environmental stressors, design constraints and loading scenarios, that work in congress to cause an unpredicted fracture or acceleration of degradation leading to failure. This work covers a case study analyzing the combined influence of various factors resulting in a delayed cracking failure observed in transmission gear assemblies. The gear assembly was comprised of a single ring gear electron beam (EB) welded around its interior circumference onto a mated shaft. Both components were composed of a proprietary high strength steel. Mated surfaces were cleaned prior to assembly. The surface-tempered, low-vacuum EB weld was UT inspected after assembly, and in all cases no solidification cracks were detected in the failed components. The delayed crack feature was seemingly presenting itself at random with no correlation to time of production, lot of material, or process change. Combining experience in steel process metallurgy, fractographic analysis and corrosion mechanism characterization, a root cause was elucidated that tied together the many disparate factors that synergized in select gear assemblies, thus allowing for a more informed set of corrective actions to be put in place to avoid further failures.

Corrosion Protection in Electric Vehicles

Karsten Lessmann • Pfinder KG

Corrosion protection in electric vehicles comprises three elements:

- Battery and battery frame
- Car body
- Chassis parts

and the contact areas between these elements.

The requirements are sometimes different and more complex compared to the conventional corrosion protection systems for cars with combustion engines. One additional important requirement which gets along with the Lithium-Ion Batteries is the resistance to flame propagation. It is well known that in case of a malfunction batteries can reach extreme high temperatures. This can lead to flame building and burning of the vehicle. The passengers have to get the chance to leave the burning vehicle. Therefore it is imperative that all used materials, including the corrosion protection materials are tested thoroughly in regards to fire behavior.

Examples will be given for efficient corrosion protection for battery frames, car bodies and chassis parts with waterborne cavity waxes and/or underbody- or stone chip protection. These corrosion protection materials cover the critical areas like welding seams, sockets, flanges, screws, seals, underbody areas in order to avoid any ingress of moisture, which is the basic prerequisite for corrosion and further subsequent damage.

Cu behaviors in CALP process, post heat treatment and thin film pretreatment and its impact on filiform corrosion of high-Cu 6xxx Aluminum Alloys Panels

Jichao Li[a], Niamh Hosking[b], Javier Esquivel Guerrero[b], Sabrina Peczonczyk[b], Daniel Freiberg[b], Mary Lyn Lim[c], Mark McMillen[c], and Philip Dodge[a]

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Scribe creep tests are frequently used to assess the corrosion performance of the E-coated and painted metals used in the vehicle body structure. Scribe creep measurements on coated aluminium alloys can be challenging for several reasons, including their low corrosion rates in cyclic corrosion tests and the localized nature of the corrosion mode, which is not well quantified by the creep length measurement. Nonetheless, important findings for aluminium alloy corrosion have been established using the scribe creep method, such as that grinding the aluminium substrate and higher copper content in the alloy composition have a negative impact on scribe creep performance of the coated panel. However, these general findings are not sufficient for a mechanistic understanding of the coated panel scribe creep performance.

In this work, we undertook a systematic exploration of the interaction effects of the alloy microstructure and pre-treatment conditions on the scribe creep performance by analysis of a single AA6111 substrate with controlled variations in thermal treatments, cleaning conditions, and pre-treatment parameters. A combination of surface analysis and electrochemical techniques was used to characterize the alloy surface condition at each stage of the pre-treatment process. A clear dependence of scribe creep resistance under cyclic corrosion conditions on the thermal history (i.e., microstructure) of the AA6111 alloy was established. Specifically, a strong influence of the temper, T4 versus T82, was observed, with higher corrosion activity measured for the former. Cleaning time and copper ion additions to the pre-treatment bath also had a significant impact on the coated panel corrosion resistance, although these effects were minimized when the substrate was in the T82 condition. Copper enrichment of the AA6111 surface observed under certain cleaning and pre-treatment conditions was not itself a root cause for reduced corrosion performance. The efficacy of thin-film pre-treatments in the scribe creep performance of automotive panels depends on the system interactions between the pretreatment and the substrate microstructure, and not on cleaning and pre-treatment parameters alone.

Evaluation of the Corrosion Characteristics of SLM AlSi10Mg Welded with ER5356 and ER4047 Filler Wire

Emily McCloy, Niamh Hosking, Jo Ann Clark, and John Henshaw • University of Tulsa

Additive manufacturing (AM) is a comparatively new manufacturing process that allows for the creation of complex structures not previously possible with traditional methods like casting, machining, and extruding. This study focuses on one form of additive manufacturing known as Selective Laser Melting (SLM) which is commonly used on the aluminum casting alloy AlSi10Mg. SLM AlSi10Mg is a new material with much potential, but most of the current literature studying its corrosion characteristics either examine it in isolation from other materials or focus on joining processes other than the Gas Metal Arc Welding (GMAW) commonly used in the automotive industry. As such, the corrosion characteristics of this material and its welds are not well understood.

To better understand this, coupons of SLM AlSi10Mg were butt welded to Aluminum Alloy 6082-T6 (AA6082) extrusion using GMAW with ER5356 and ER4047 filler wire. A third set had Aluminum Alloy 5754 (AA5754) substrate and ER5356 filler wire, which serves as a baseline for Stress Corrosion Cracking (SCC) susceptibility. Some specimens were also sensitized, which is a process that makes 5xxx alloys susceptible to SCC [1]. The corrosion evaluation methods performed are those in Ford L-3190, ASTM G67, and ASTM G44. This study serves as an initial investigation into the corrosion characteristics of welded SLM AlSi10Mg assemblies. In general, specimens with welds of ER4047 filler wire had less severe corrosion than those with ER5356 filler wire, although more work is needed to fully explain the observed corrosion and suitability of the test methods. Specimens with ER4047 filler wire also performed better in tensile tests, even though ER5356 is listed as stronger on the datasheets. This merits further study since ER5356 is chosen for its strength and the reason for including ER4047 was as an alternative with lower SCC risk. Finally, an initial comparison of the test methods suggests that L-3190 is useful for understanding typical corrosion behavior; SCC from G44 has not yet been observed and further testing is required to determine if the fixtures used are capable of inducing SCC, and G67 may not be useful for predicting SCC in these samples due to high mass losses on unsensitized welds with ER5356 filler wire.

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[2] McMahon, M. E., Haines, R. L., Steiner, P. J., Schulte, J. M., Fakler, S. E. and Burns, J. T. "Beta Phase Distribution in Al-Mg Alloys of Varying Composition and Temper." Corrosion Science Vol. 169 (2020): p. 108618. doi:10.1016/j.corsci.2020.108618.

Using Computational Corrosion Analysis to Deploy Corrosion Prevention & Control in Automotive Design

Alan Rose[a], Keith Legg[a], Siva Palani[a], Julio Mendez[a], Jeremy Hanke[b], and Christopher Lueth[b]

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Why bother with computational corrosion analysis for vehicles? With the increasing emphasis on lightweighting, the automotive industry is facing many of the same corrosion issues that bedevil the aerospace and defense (A&D) sectors. Automotive companies can therefore benefit from some of the costly lessons learned by A&D.

Apart from the obvious impact on safety, reliability and warranty, it has been shown that globally, corrosion costs about 4% of gross domestic product. Other studies have determined that about 30% of these costs can be avoided with better upfront design and material selection, while the US Navy estimates that 40% of corrosion costs can be eliminated by better design.

It is actually mandated in law that corrosion prevention and control planning be carried out for US federal military acquisitions. A number of tools have been developed to help with this. For example, MIL-STD-1568D states that "Modeling and validation testing shall be performed to identify corrosion-prone locations". Additionally, the recent revision of MIL-STD-889D for galvanic corrosion of electrically conductive materials introduces a paradigm shift, in that galvanic corrosion will no longer be estimated by the use of a table of electric potentials, but quantified by the calculation of galvanic current, based on a curated material database acquired using a consistent methodology defined in the specification. The tools that we have developed for this type of analysis in A&D are equally useful for Automotive.

This paper will present and discuss the challenges in implementing a consistent corrosion analysis capability across enterprises. We will introduce a workflow that incorporates a quick galvanic corrosion calculation using the Corrosion Djinn® software. Full 3-dimensional, deeper dive analyses are then presented using the Siemens Teamcenter® and multi-physics software Simcenter STAR-CCM+ combined with the Corrdesa electrochemical database to predict corrosion rate maps over 3D CAD components. This process will be demonstrated with examples of computational corrosion analysis on F/A-18 components.

Development of a Computational Framework for Prediction of Galvanic Corrosion for Automotive Applications

L. Saberi and M. Amiri • George Mason University

The operating environment of vehicles varies to a good degree depending upon the location, usage requirements, and other ground activities. All these conditions promote corrosion of one type or the other. In particular, galvanic corrosion is a major concern in automotive industry. Further, the actual environment is such that the materials are subjected to dynamic thin film electrolyte under cyclic wet-dry conditions. Thus, developing a computational framework that can monitor and track the galvanic corrosion damage in many areas of the vehicle structure based on operating environment and usage history data is crucial. We demonstrate the proposed computational framework for a galvanic couple of Stainless Steel (SS) 316L and Aluminum (AA) 7050-T7451 under varying thin film electrolyte. Further, since the actual environment to which a vehicle is exposed during its usage life is uncertain, a probabilistic analysis is considered to account for variation in environmental factors such as temperature and relative humidity.

The Mitigation of Galvanic Corrosion between Mechanically Coupled Aluminum and Carbon-Fiber Reinforced Polymer Matrix Composites

Raghu Srinivasana and Lloyd Hiharab

The use of an insulating skirt to mitigate galvanic action between mechanically coupled 6061-T6 aluminum (Al) and electrically conductive carbon fiber reinforced (CFR) polymer-matrix composites (PMCs) was assessed, analyzed and modeled. The galvanic corrosion current as a function of time between the 6061-T6 Al and CFR PMCs for a range of insulative skirt lengths, ls, and sodium chloride (NaCl) salt loadings, m′, in a humidity chamber at 30°C and 90% relative humidity (RH) were monitored. Polarization experiments were conducted on 6061-T6 Al and conductive CFR PMC electrodes to study the mechanisms governing galvanic corrosion in solutions ranging from 0-ppm chloride (Cl–) to 20,000 ppm Cl– concentrations. Based on the electrochemical characteristics of Al and the CFR PMC and the ohmic loss within the galvanic couple, a model was developed that related the galvanic corrosion rate (iGalv) to the value of ls/m′, which is the ratio of the insulating skirt length to salt loading. Experimental data from the polarization experiments as well as data from monitoring the galvanic couples in the humidity-chamber galvanic experiments were used to generate plots of log ls/m′ vs log iGalv, which can be used in design to determine proper skirt length for various environments (based on salt-loading levels) to limit the galvanic corrosion rate to a specified value. The effect of hydrophobic coatings on insulative skirts to mitigate galvanic corrosion between mechanically fastened aluminum alloy and CFR PMC were also studied in humidity-chamber experiments and outdoor exposure tests. The utilization of hydrophobic coatings on the insulative skirt can help to attenuate galvanic corrosion by disrupting the formation of a continuous electrolyte film. Results from humidity-chamber experiments showed that the Siloxel™ coatings with a contact angle of 90° generally reduced galvanic corrosion rates by three orders of magnitude for a given skirt length. When the skirt (coated with Siloxel™), however, was at an optimal length of only 0.64 cm, the galvanic current decreased by approximately six orders of magnitude due to capillary effects that wicked electrolyte away from the edge of the skirt. Skirts with different types of coatings (i.e., Siloxel™, polyurethane, epoxy, and latex) of various levels of hydrophobicity were also studied to determine the effect of the coating contact angle on the galvanic current. The natural salt particles deposited on the Siloxel™ coated 0.64 cm shorter skirt lengths did not support the capillary wicking mechanism found in the laboratory humidity chamber experiments; hence, the shorter hydrophobic skirts were not effective in attenuating galvanic corrosion in the field.

Expanded Cure Capabilities of Electrocoat to Resolve EV Challenges

David Stone • PPG

PPG is facilitating vehicle electrification and sustainability in manufacturing through the development of innovative materials solutions. In this presentation, we will discuss new electrocoat technologies with an expanded bake window and a lower temperature cure capability. These technologies enable new BEV design criteria while also reducing energy consumption in the automobile manufacturing process.