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Electrochemical study of unmodified and inhibitor doped silane films for corrosion protection of 2024 aluminum alloy

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Statement of the Problem: Excellent adhesion and self-healing properties conferred by chromate conversion coatings (CCC) made them the pretreatment method of choice for metals like aluminum and steels. However, due to the carcinogenic and mutagenic nature of hexavalent chromate species research to find adequate alternatives is on-going. Silanes, capable of forming a dense barrier layer as well as allowing formation of bonds with the metallic substrate and organic top coat, have been investigated as alternatives. However, the effect of number of hydrolysable groups per silane molecule and inhibitor ions have not been studied together. The purpose of this study is to compare the performance of gamma-(aminopropyl)triethoxysilane and bis-trimethoxysilane and effect of cerium ions on corrosion resistance. Methodology & Orientation: The coatings were prepared using immersion method and then cured. The focus of study was the interaction between AA2024 substrate, silane and inhibitor ionic species. Morphology of the films was studied by scanning electron microscopy. Corrosion performance was investigated via DC polarization, electrochemical impedance spectroscopy and energy dispersive x-ray spectroscopy. Findings: The number of hydrolysable groups have a significant impact on film uniformity and barrier properties. Additional hydrolysable groups in bis-trimethoxysilane allow for a marked improvement in corrosion protection over the gamma-(aminopropyl)triethoxysilane. The addition of cerium ions further enhances the performance of the bis-trimethoxysilane by imparting a self-healing effect to the silane layer. Conclusion & Significance: An increased number of hydrolysable groups in a silane molecule allow for the formation of a denser metal-silane interface along with a more uniform coating. A functional group can have a positive or negative impact on the silane layer performance. Cerium ions can provide short-term self-healing effect. Areas of future improvement are identified.

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