ARC Centre of Excellence Design in Light Metals

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The Alloy Surface Pretreatment And Surface-Silane Interactions In Silane Based Conversion Coatings For AA2024-T3

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Introduction

Long term solution to the problem of finding a suitable alternative to the currently employed chromate conversion coating requires in-depth understanding of different aspects of any alternative coating system proposed as a replacement. Silane based coating systems hold promise in this regard. However, the surface and interface properties of these coatings are not well understood and need to be explored for establishing their long term reliability.

The different unknown aspects relating to the surface pretreatments for silane application are about the desirability of the extent of roughness, nature of topography, presence or absence of intermetallics, and oxide/hydroxyl group concentrations on the surface. The effect of these on the chemical interaction between the coating system and the pretreated substrate containing phases in combination, and their consequential effect on the coating performance remain largely unexplored.

Aim

The proposed research aims to address the issues related to

(i) the desirable surface pretreatments for the alloy for application of silane coatings

(ii) the interaction between the silane coating system and the constituents of the alloy, and

(iii) dependence of corrosion performance on the surface-silane interaction.

Research Hypothesis

The optimum surface morphology, roughness and chemical composition for application of silane can be arrived at by surface pre-treatment investigations on the alloy and its constituents. The electrochemical nature of the pre-treated constituents of the alloy governs the interactions with the silane coating system. Understanding of the surface-silane interactions is necessary to optimize coating system parameters which ensure uniform coating and improved corrosion performance of AA2024-T3.

Preliminary Surface Studies by AFM & XPS

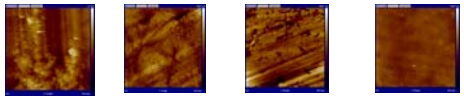
SURFACE PRETREATMENTS ON AA2024-T3

Specimen: (i) As rolled sheet (ii) 1200 grit finish

1.Degreasing (MEK: methyl ethyl ketone)
2. Alkali treatment (Uniclean1020, room temperature)
3. Desmutting (Alprep230, room temperature)
4. Silane coating (vinylsilane, TEOS, SiO_2 nanoparticles)

AFM (scale: 50μm×50μm)

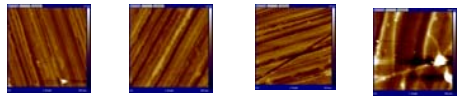
(I) As rolled sheet (RR: RMS Roughness)



MEK clean RR 158.0nm | Alkali RR 63.0nm | Desmutted RR 98.4nm | Silane coated RR 23.1nm

- Pretreatments influence surface roughness
- Roughness of silane coating comparable to SiO_2 size

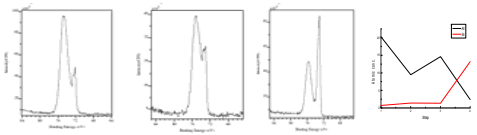
(II) 1200grit finish



MEK clean RR 192.0nm | Alkali RR 164.0nm | Desmutted RR 181.0nm | Silane coated RR 160.nm

- Trade-off between roughness & crack formation

XPS (Al 2p)

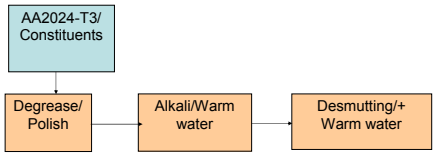


MEK clean | Alkali | After Desmutting | Four stages

- Gradual reduction of oxide layer due to pretreatments
- Cu and Al detected on silane coated layer indicates imperfections in the coating arising possibly due to areas not reacting with silane coating

Proposed Research Plan

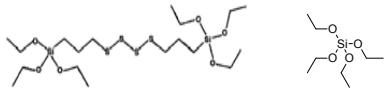
1. Surface Pretreatments on Al, AA2024-T3, Al-4%Cu solid solution, and Intermetallics



2. Silane-surface interactions between BTESPT/ BTESPT+TEOS and pretreated alloy/ constituents

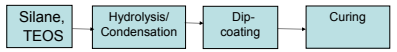
BTESPT: Bis-[3-(triethoxysilyl)propyl]tetrasulfide

TEOS: Tetraethylorthosilicate

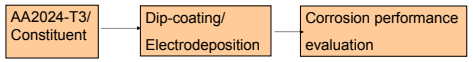


BTESPT $(H_5C_2O)_3Si\text{-}(CH_2)_3\text{-}S_4\text{-}(CH_2)_3\text{-}Si()C_2H_5)_3$

TEOS $Si(OC_2H_5)_4$



3. Corrosion performance testing of alloy/constituent coated with optimized coating parameters



4. Characterization of pretreated and coated alloy/constituents

AFM: Morphology and roughness
RA-FTIR: chemical composition
Raman mapping: Distribution of siloxane, silanol, other groups on coated specimen
SEM-EDXS: Elemental mapping
XPS/AES Oxide thickness, composition, depth profile and mapping of etched face for interaction of alloy constituents with silane
TOF-SIMS: O/OH ratio, metal-O-Si bonds
DC Polarization Tests/EIS: Corrosion

Expected Results

- Understanding of surface pretreatments methodology which provides suitable physical characteristics and chemical composition of alloy AA2024-T3 surface for application of silane coatings.
- Elucidation of the chemical interaction between the silane and alloy constituents. These are required for optimization of coating system parameters for application of homogeneous, pore-free silane films.
- Elucidation of metal-oxygen-silicon covalent bonding through investigations on silane-surface interface for a variety of alloy constituents.
- Silane coatings for AA2024-T3 providing better corrosion performance.

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