Effect of the metallic surface pre-treatment on the corrosion behaviour of sol-gel hybrid coatings applied on EN AW-6063 alloy

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The organic-inorganic hybrid silane based sol-gel coatings have proved to be a promising environmentally friendly alternative to Cr(VI) for the anticorrosive protection of aluminium alloys [1]. As a result of the hydrolysis and condensation reactions involved in the sol-gel process a protective solid film is formed on metallic substrate surface, strongly adherent due to the establishment of chemical bonds such as Al–O–Si [1,2]. In this context, the pre-treatment of aluminium surface plays an important role in the corrosion resistance of sol-gel coated aluminium. Not only it removes surface contaminants and intermetallic compounds prone to develop pitting, but also provides a clean surface where a more homogenous native oxide is formed to which the sol gel film is attached [3].

In this work, the effect of several pre-treatments of aluminium surface on the corrosion behaviour of sol–gel hybrid coated EN AW 6063 alloy was studied. Four pre-treatments were studied, which included: solvent degreasing; alkaline degreasing followed by acid chemical etching; alkaline degreasing followed by alkaline plus acid chemical etching and alkaline degreasing followed by acid chemical etching and oxide growth in boiling water. The morphology of aluminium surface was analysed by SEM/EDS showing differences depending on the pre-treatment. The alkaline plus acid cleaned samples exhibited a very smooth deoxidized surface, in contrast with all the others. The surface of the samples subjected to the oxide growth step exhibited a more homogenous and denser surface oxide layer.

A sol-gel hybrid coating, synthesized from glycidoxypropyltrimethoxysilane (GPTMS) and zirconium n-propoxide (TPOZ) precursors, was applied to EN AW-6063 alloy by dip-coating. The corrosion behaviour of the different pre-treated aluminium samples coated with this hybrid film was evaluated by Electrochemical Impedance Spectroscopy (EIS) and by an accelerated corrosion test comprising 1000 h exposure in a wet chamber (40°C; 82%RH) after 1 min contact with HCl (38%). Both tests revealed that the pre-treatment including the oxide growth final step had significantly improved the overall corrosion resistance of the coated aluminium alloy samples. However, without this additional step, the best barrier properties were achieved by the coating applied to the alkaline plus acid cleaned samples.

Complimentary to the corrosion study, the adhesion of the hybrid sol-gel was evaluated by the cross-cut and bend tests carried out after exposure. According to the cross cut test, carried out in dry conditions, the coating adhesion was good for all aluminium surface pre-treatments applied. However, the bend test, carried out after 1000 h exposure in the wet chamber, induced cracking and detachment of the hybrid coating that were more evident in the alkaline plus acid cleaned sample, what was attributed to the smoother, deoxidized surface of this substrate.

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