EIS study of amine cured epoxy-silica-zirconia sol-gel coatings for corrosion protection of the aluminium alloy EN AW 6063

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The organic-inorganic hybrid sol-gel films have been reported as an environmentally friendly anti-corrosion pre-treatment for several metals. These types of coatings present combined mechanical and chemical properties typical of inorganic ceramics and of organic polymers [1]. Among these, the epoxy-silane based hybrid sol-gel coatings are of particular interest due to the increased properties of flexibility, density and functional compatibility with organic coatings achieved as a result of the epoxide organic group present [1-3]. During the synthesis of these coatings occurs the simultaneous formation of an organic network through epoxide rings opening and polymerization, and of an inorganic siloxane network through the hydrolysis and subsequent condensation of the silicon alkoxide groups. Uncatalysed organic polymerization usually requires elevated temperature. However, by the addition of amine curing agents it is possible to promote the organic network formation at low temperature [4], with inherent energy savings.

In this paper, epoxy-silica-zirconia hybrid sol-gel coatings were synthesized from glycidoxypropyltrimethoxysilane (GPTMS) and zirconium n-propoxide (TPOZ) precursors, applied to EN AW-6060 alloy by dip-coating and cured at room temperature using the amine crosslinker diethylenetriamine (DETA), in different concentrations (GPTMS/amine-$H_{reactive}$ molar ratios: 1.5 and 1), and a tri-functional amino-silane in that molar ratio of 1. The evolution of the curing process and the corrosion behaviour of the coated aluminium alloy specimens were evaluated by Electrochemical Impedance Spectroscopy (EIS) in 0.5 M NaCl. The morphology and surface chemistry of the hybrid coatings were also characterized by Energy Dispersive Spectroscopy (EDS) coupled to Scanning Electron Microscopy (SEM) and by Fourier Transform Infrared Spectroscopy (FTIR). The results obtained revealed that the sol-gel coatings with less amine require longer times to finish cure. Once cured, these coatings have shown the best anticorrosive performance with time. It was found that increasing amine concentration led to a more cross linked organic network, resulting in higher initial coatings resistance, however it has turned coatings more hydrophilic, prone to rapid degradation in water.

References

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