Influence of the pH on the corrosion protection of epoxy-silica-zirconia sol-gel coatings applied on EN AW-6063 aluminium alloy

I. R. Fontinha[a], M. M. Salta[a], M. L. Zheludkevich[b], M. G. S Ferreira[b], R. B. Figueira[a,c], E. V. Pereira[a], C.J.R. Silva[c]

[a]LNEC – Laboratório Nacional de Engenharia Civil, Av. do Brasil 101, 1700-066 Lisboa, Portugal,
[b]University of Aveiro, CICECO, Department of Materials and Ceramic Engineering 3810-193 Aveiro, Portugal.
[c]University Minho, Centro de Química, Braga, Portugal.

Aluminium alloys properties such as light weight, corrosion resistance, with inherent high durability, in combination with the good strength-to-weight ratio, justify the extensive use of these alloys in a broad range of industrial applications. Transport, building, packaging and energy industries are the main end-use markets of aluminium alloys, each one requiring specific aluminium alloys properties and products tailored to their needs. The aluminium alloys of 6000 series, for instance, are particularly suited for the building industry due to their good corrosion resistance, which derives from the presence of a thin oxide layer that naturally forms on its surface when exposed to oxygen. However, the protective efficacy of this natural oxide layer is highly reduced in acidic (polluted) and/or marine environments, in which these alloys can suffer severe corrosion [1]. Therefore, architectural aluminium components are often surface treated to increase their durability and aesthetical appearance, reducing maintenance needs. Coating, namely, with thermoset powder paints is one of the most common surface treatments applied to architectural aluminium components.

Coating an aluminium alloy requires its surface pre-treatment so as to promote adherence of the organic coating. Chromate based chemical conversion layers (CCC) have been extensively used for that purpose since they not only provide very good adhesion of organic coatings, but also afford corrosion protection, both by barrier and self-healing effect [2]. However, the use of these surface treatments has been under severe restrictions in the European Community and North America, due to Cr (VI) toxicity and carcinogenic effects [3]. Within building industry, several “green” alternative treatments are already being applied, however, they lack the anticorrosive action of the Cr(VI) compounds. Another alternative route, still under development, includes sol-gel silane based coatings, in particular, the organic-inorganic hybrid (OIH) ones. This type of coatings have been pointed out as a very promising environmentally friendly alternative to chromate pre-treatments, since they not only promote adherence, but also provide corrosion protection by barrier effect and in addition can incorporate corrosion inhibitors in their structure [4][5].

In this work, organic-inorganic hybrid (OIH) coatings with in situ produced zirconia nanoparticles were synthesized from glycidoxypropyltrimethoxysilane (GPTMS) and zirconium n- propoxide (TPOZ) precursors by the sol-gel process. Cerium nitrate was added during synthesis to be incorporated in the nanoparticles and act as corrosion inhibitor. The synthesized OIH nanostructured coatings were applied on EN AW-6063 alloy by dip-coating. Then cerium doped and undoped OIH coated aluminium alloy specimens were exposed to neutral, acidic (pH~3) and alkaline (pH~10) chloride solutions to assess coating chemical stability and anticorrosive properties in those media, because powder coatings for architecture are usually required to be resistant both to acids and alkalis. The alkaline media was produced by the dissolution of cement paste in the chloride solution.

The corrosion behaviour was evaluated by EIS (electrochemical impedance spectroscopy) during 14 days and after that time SEM/EDS analyses of the coatings surface were carried out. The results obtained revealed that OIH coatings present the best performance in the neutral chloride solution and the worst in the acidic chloride solution. In the alkaline chloride solution, in which the decrease in coatings resistance was very high, the cerium doped coatings exhibited much better anticorrosive performance than the undoped ones, clearly evidencing the beneficial role of the corrosion inhibitor in this media.

References

[1] ASM International. Aluminium and Aluminium alloys – Specialty handbook, 4th Edition, J. R. Davis (Ed.), ASM International, Ohio, 1994.

[2] M. W. Kendig, R. G. Buchheit, Corrosion Inhibition of Aluminium and Aluminium Alloys by Soluble Chromates, Chromate coatings, and Chromate-Free Coatings, Corrosion 59 (2003) 379.

[3] R. Akid, M. Gobara, H. Wang, Corrosion protection performance of novel hybrid polyaniline/sol-gel coatings on an aluminium 2024 alloy in neutral, alkaline and acidic solution, Electrochimica Acta 56 (2011) 2483-2492.

[4] M. L. Zheludkevich, I. Miranda Salvado, M. G. S. Ferreira, Sol–gel coatings for corrosion protection of metals, J. Mater. Chem. 15 (2005) 5099-5111.

[5] I. Rute Fontinha, M. Manuela Salta, M. Zheludkevich, M.G.S Ferreira, Effect of Inorganic Content on the Performance of Anticorrosive Hybrid Sol-Gel Coated EN AW-6063 Alloy, Materials Science Forum Vols. 730-732 (2013) 745-750.