

Corrosion behaviour of physical vapour deposition aluminium-based coatings on 2024 aluminium alloy

J. C. Salvador Fernandes and Mário G. S. Ferreira

Departamento de Engenharia Química, Instituto Superior Técnico, 1096 Lisboa Codex (Portugal)

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Abstract

Pure aluminium and Al–Li coatings applied by physical vapour deposition on 2024 aluminium alloy were tested for their corrosion properties. It was concluded that both the effects of self-dissolution of the coating and cathodic protection should be considered in the assessment. The results favour the use of pure aluminium instead of Al–Li alloy.

1. Introduction

The main objective of coatings applied on aluminium alloys by physical vapour deposition (PVD) is to improve the corrosion resistance of the substrate in the same way as cladding applied to thin layer sheets, *i.e.* by forming a surface deposit which confers to the system an improved corrosion resistance. However, the application method must not create incipient cracks which would adversely affect the fatigue strength of the substrate.

In this work two coatings, aluminium (99.9% Al) and Al–Li (2.55% Li), were applied by PVD on 2024 aluminium alloy and tested by electrochemical methods in order to assess their corrosion performance in a sulphate solution.

2. Experimental details

Potential measurements were carried out for the coated aluminium alloy *vs.* the saturated calomel electrode (SCE) with a high impedance voltmeter.

Polarization plots were obtained for the coated specimens and the base aluminium alloy by potentiodynamic experiments. These include a Thompson potentiostat associated with a linear sweep generator. The data acquisition was done through an HP-87 microcomputer via two digital high precision voltmeters.

3. Results and conclusions

Table 1 shows the free-corrosion potential of the aluminium alloy and coated alloys in 0.1N K₂SO₄ solution.

In both cases the coated specimens show lower potentials than the bare aluminium alloy, the potential of the lithium-containing coating being much lower than that of the aluminium coating. However, both coatings are anodic relative to the substrate.

This means that if for some reason the coating is

TABLE 1. Free-corrosion potential of the specimens

Specimen	E_{corr} (mV vs. SCE)
2024 Alloy	–280
2024 + Al	–450
2024 + Al–Li	–1250

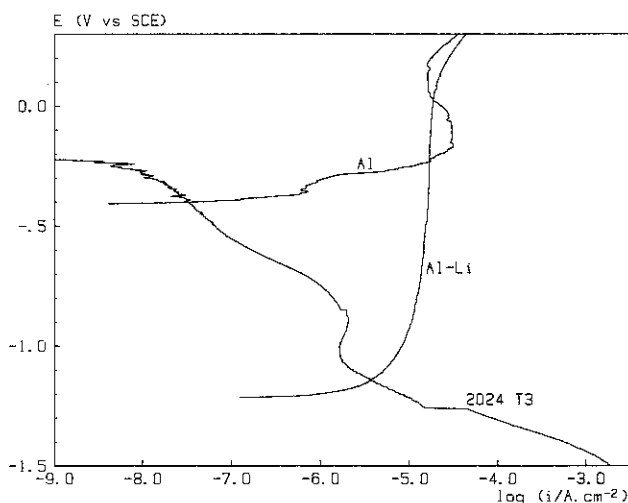


Fig. 1. Cathodic and anodic polarization plots of uncoated 2024 alloy and aluminium and Al–Li coatings in 0.1N K₂SO₄ solution.

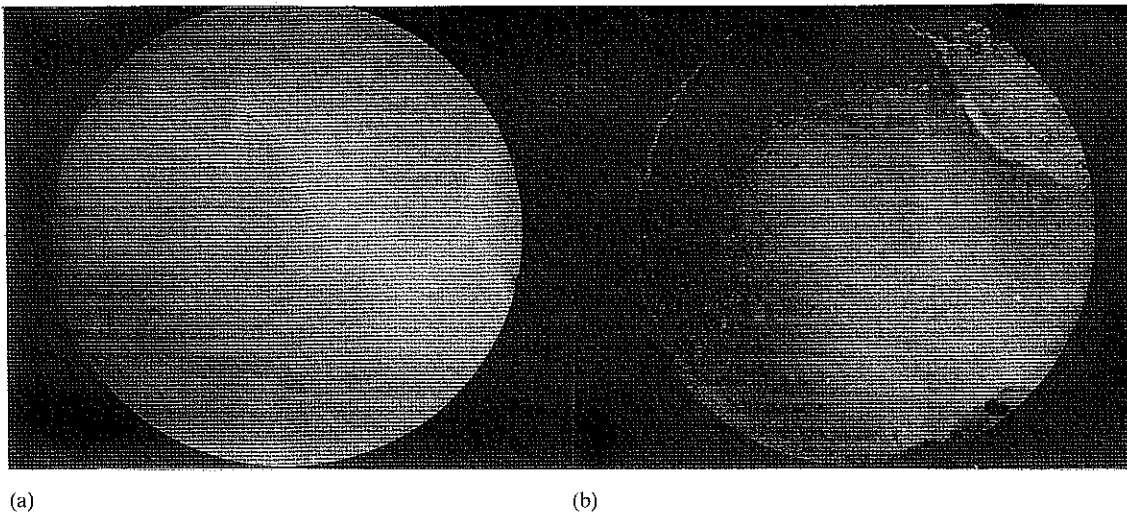


Fig. 2. Coated specimens after anodic polarization in 0.1N K_2SO_4 solution: (a) aluminium; (b) Al-Li.

damaged and/or faulty, the substrate will behave as a cathode, whereas the coating will be the anode, thus suffering corrosion. The substrate will then be protected by the coating and this process is the basis of cathodic protection.

In order to test the performance of the two coatings when called to perform as sacrificial anodes in a cathodic protection system, the anodic polarization plots of the two coated specimens were overlapped with the cathodic polarization plot of the substrate alloy. The results in Fig. 1 show that the current density at the interception of the two plots (which would correspond to the cathodic protection current) is higher for the Al-Li alloy than for the aluminium coating.

This means, from the cathodic protection point of view, a better performance of the Al-Li alloy, which supplies a larger protection current to the substrate. However, it also means a high self-dissolution rate of the coating, which will only last for short periods.

Thus the comparison of the two coatings has to take into account the two aspects above. A higher dissolution rate of the coating means a loss of protection, by losing both the coating and the cathodic protection effect.

Figure 2, which shows the two coated specimens after

polarization in contact with the solution, makes apparent the higher dissolution rate for the Al-Li coating, which nearly disappeared from the surface.

In conclusion, it seems wiser to coat with pure aluminium instead of Al-Li. Lithium has been used as an additive to aluminium for making lighter alloys and is very promising in aeronautics applications [1, 2]. However, the role of lithium as far as corrosion is concerned is still not completely known [3, 4], and although in some cases it can improve the corrosion resistance of aluminium alloys, in other cases it may have a deleterious effect. Metallurgical aspects such as solubility and phase formation should be taken into account and these aspects depend on the processes of alloy formation.

References

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