

Intergranular Corrosion of Aluminum 2024-T351 Using Different Constant Extension Rate and Electrochemical Noise

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This study presents experimental results about the susceptibility to the initiation, growth and crack propagation in aluminum 2024-T351 (90-94 wt % Al, 3.8-4.9 wt % Cu, 1.2-1.8 wt % Mg). The experimental results are obtained from constant extension rate test (CERT) technique, using three different strain rate (1×10^{-6} , 2×10^{-6} and 7×10^{-6} /s⁻¹), being used also an analysis by electrochemical noise as complement to the study. According to the fractography obtained by scanning electron microscope (SEM), the solution used to these concentrations, did not influence in the samples so that these failed, pits are not perceived and nor another form of corrosion on the surface the material, reason why attributes to the failure is purely mechanics strengths.

Introduction

The stress corrosion cracking (SCC) is a very dangerous corrosion because it happens, when certain materials are under the joint operation of tensile stress an specific corrosive environment, and causes nucleation, growth and propagation of fissures at very low levels of mechanical stress. The intention of this work is to determine if this alloy in aggressive means of NaCl, at three different slow rate of strain (1×10^{-6} /s⁻¹, 2×10^{-6} /s⁻¹ and 7×10^{-6} /s⁻¹), is susceptible to this type of corrosion, using technique CERT. The alloy aluminum-copper-magnesium 2024-T351, is reinforced mainly by the mechanisms of hardening by solid solution, and hardening by precipitation, and is used in the aeronautics industry by it is main characteristic, his relatively low density [2].

Experimental Methodology

The material used for this work was an aluminum alloy bar 2024 - T351 of ½ inch of diameter, which was machinability as it indicates the norm NACE Standard TMO177-96. The alloy contains around 4.5 % of Cu, 1.5 % of Mg and 0.6 % of Mn, and in table I their mechanical properties appear [3]. This alloy is reinforced mainly by the mechanisms of hardening by solid solution, and hardening by precipitation for that reason its T351 nomenclature. A intermetallic compound with a approximated composition to the Al₂CuMg is the main one precipitated hardened [4].

TABLE I. Mechanical properties.

Ultimate Tension Stress (kg/mm ²)	Yield Strength (kg/mm ²)	% de Elongation	Hardness Brinell
43.37662	31.63942	10	120

The used equipment was CERT machine, test at rate of constant extension. The monitored of Electrochemical Noise was obtained by the analytical potenciostat. The test environments were glycerol (inert), 3.5% and 5% NaCl. The tested specimens were analyzed by microscopy.

Results and Discussions

The obtained results of the curves stress-deformation are in table II, where it is possible to be observed that there is not much difference between the ultimate tension stress of inert means and the maximum stress of aggressive environment one is observed the time of failure. The series of time in current and potential, obtained for specimens evaluated are shown in figure 1, and In

fractography (figure 2) there is evidence of no attack by aggressive environment.

TABLE II. Results of the curves stress-deformation

Strain rate (/s ⁻¹)	Environment	Ultimate Tension Stress (kg/mm ²)	Failure time (h)
1×10^{-6}	Inerte	48.616	72.06
	NaCl 3.5 %	47.791	73.54
	NaCl 5 %	47.797	77.63
2×10^{-6}	Inerte	48.603	36.00
	NaCl 3.5 %	48.053	35.24
	NaCl 5 %	48.517	37.30
7×10^{-6}	Inerte	48.659	10.00
	NaCl 3.5 %	47.532	10.00
	NaCl 5 %	47.644	10.63

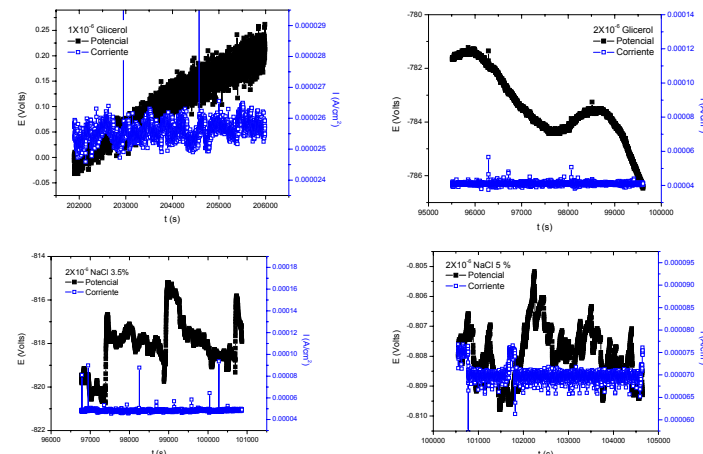


Figure 1. Series of time in potential and current a) inert environment 1×10^{-6} /s⁻¹, b) inert environment 2×10^{-6} /s⁻¹, c) 3.5% NaCl to 2×10^{-6} /s⁻¹, d) NaCl 5% to 2×10^{-6} /s⁻¹.

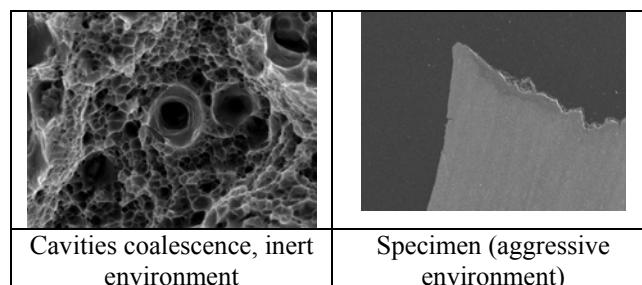


Figure 2. Obtained fractography.

Conclusions

The type of fracture that I appear in all the tried test tubes was ductile, characterized by the formation of cavities coalescence. The presented failure was due to the mechanical tension to that they were put under specimens, the aggressive environment do not have influence so that it happened the fracture of the sample, since pitting were not observed on the surface (being cause of beginning of crack). The potential and current of noise series, helped to obtain data valuable about the susceptibility of aluminum alloy to undergo stress corrosion cracking. This aluminum 2024-T351 is immune to stress corrosion cracking in environment aggressive by sodium chloride 3.5% and 5%.

References

- C. A. M. Dutra, M. C. Pereira, E. N. Codaro e R. Z. Nakarazato. Correlação entre Microestrucutra e Corrosão da Liga 2024- T351. (2002)
- K. Myer. Handbook of Materials Selection. Aluminum Alloys. USA (2002)
- ASTM B 211M. Standar Specification for Aluminum and Aluminum – Alloy Bar, Rod, and Wire [Metric] (1995)
- W. F. Smith. Fundamentos de la Ciencia e Ingeniería de Materiales. McGraw – Hill, Madrid. Pp, 552 – 555 (1993)