Metrohm Autolab

Application Area: Corrosion

ASTM G100: Cyclic Galvanostaircase Polarization

Keywords

Corrosion Applications: Aluminum alloy, ASTM standards, Cyclic galvanostatic, Galvanostaircase, Polarization, Test method, ASTM G100

Introduction

The ASTM standard G100 is an electrochemical method to test localized corrosion of aluminum 3003-H14 and other alloys[1]. A cyclic galvanostatic staircase polarization (galvanostaircase) is composed of an upward and a downward scan. The potential values at the end of each step are collected and linearly fitted, with regression lines extrapolated until the potential values at zero current are found, for both the upward and the downward scan. These values are the breakdown or pitting potential E_b, and the protection potential E_{prot}, respectively. The pitting potential is defined as the potential at which the current starts to rise above the passive current, during the upwards scan. The protection potential is the potential at which the current reaches the passive current, during the downward scan[2]. If the applied potential $E_{app} < E_{prot}$, no corrosion initiation is observed. When $E_{app} > E_{prot}$, then corrosion occurs, even if $E_{app} < E_b$.

Experimental setup

The experiment was carried out with an Autolab PGSTAT204, together with the 1 L Metrohm corrosion cell. The specimen was an aluminum sample, with 1 cm^2 of exposed area to the electrolyte. As counter electrode, two stainless steel rods were used, with a Ag/AgCl (3 mol/L KCl) reference electrode. (). As electrolyte, an aqueous solution 3000 ± 3 ppm (0.0516 M), of NaCl was used.

The procedure consists of applying a current density staircase, cycling from 0 µA/cm^2, to 120 µA/cm^2, and back to 0 µA/cm^2. Each step is 20 µA/cm^2 high and 120 s long.

A plot of the applied current density vs. time is shown in Figure 1.

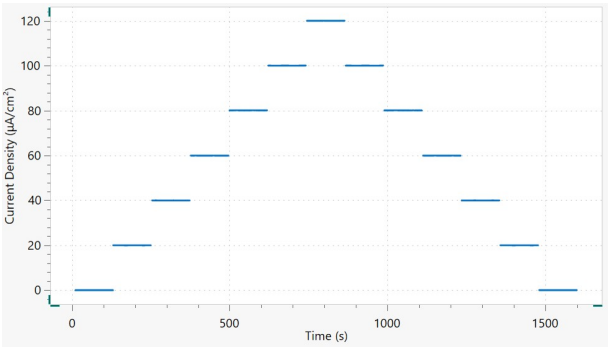

Figure 1 – Plot of the applied current density versus time.

Results and Discussion

Figure 2 shows the measured potential, together with the current density (in µA/cm^2) corresponding to each step.

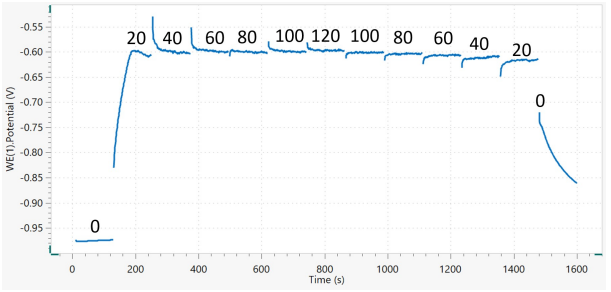

Figure 2 – Measured potential vs. time plot. Above each step, the respective current density (µA/cm^2) is shown.

Then, the last potential value of each step from 10 µA/cm^2 to 120 µA/cm^2 is collected and plotted versus time. Two plots are built: one for the upward scan, and the other for the downward scan, shown in Figure 3 and Figure 4, respectively.

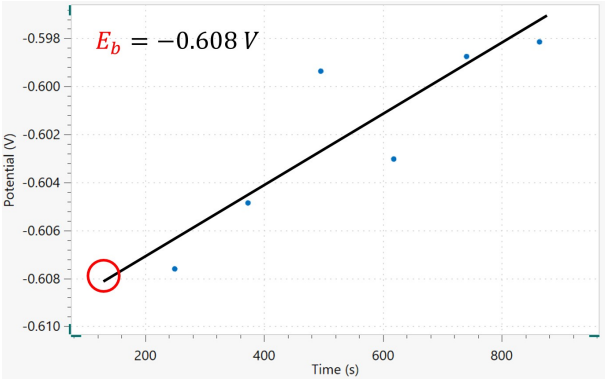

Figure 3 – Potential at the end of each upward step versus time (blue dots), with the regression line (black line).

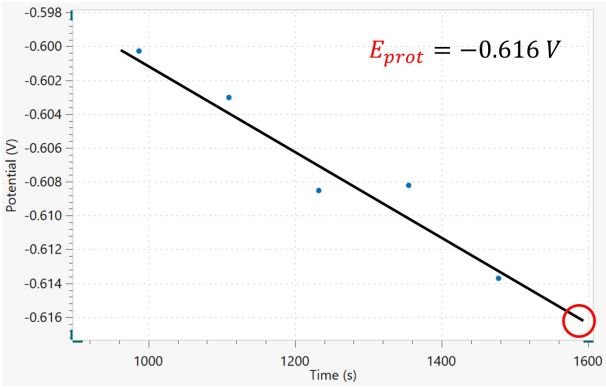

Figure 4 - Potential at the end of each downward step versus time (blue dots), with the regression line (black line).

In Figure 3 and Figure 4, the regression lines are also shown. The desired potential values are the ones at zero current. Therefore, the plots are extrapolated to 120 s for the backwards direction (Figure 3), and 120 s afterwards (Figure 4) The time of 120 s was chosen, because each current step lasts 120 s. In this way, the potential values found at the beginning of the regression of the upward scan and at the end of the regression of the downward scan give E_b and E_{prot}, respectively. Here, $E_b = -0.608\ V$ and $E_{prot} = -0.616\ V$.

As expected, E_{prot} has a lower value than E_b. However, the values differ slightly from the values found in literature[1-2]. This may be due to the different aluminum type used for these experiments, with respect to the specimen suggested by the ASTM standard.

Conclusions

In this document, it was shown how the combination of the Autolab PGSTAT204 and the 1 L corrosion cell was used to replicate the ASTM G100 standard, for testing corrosion of aluminum samples. The NOVA procedure was composed of a series of cyclic galvanostatic steps. The potential was sampled and plotted versus the time. Regression lines were calculated for both the upward and the downward scans and calculations of the breakdown and protection potentials were performed.

References

[1] ASTM G100 “Standard test method for conducting cyclic galvanostatic polarization”;

[2] Hirozawa, S.T., J. Electrochem. Soc., (1983), 130, 8, 1718

Date

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For more information

Additional information about this application note and the associated NOVA software procedure is available from your local **Metrohm distributor**. Additional instrument specification information can be found at **www.metrohm.com/en/products/electrochemistry**.