Metrohm Autolab

Application Area: Corrosion

ASTM G5: Potentiodynamic Anodic Polarization Measurements

Keywords

ASTM, standards, Potentiostatic, potentiodynamic, anodic, polarization, 430 stainless steel.

Introduction

The ASTM standard G5 is a method to test the corrosion of Type 430 stainless steel, with a potentiodynamic anodic polarization measurement.

Experimental setup

For the experiment, a 430 stainless steel disk of 1 cm^2 was immersed in an 1 N aqueous sulfuric acid solution (0.5 mol/L). As counter electrode, two Metrohm platinum sheet electrodes were used. As reference electrode, a Ag/AgCl 3 mol/L KCl Metrohm reference electrode was chosen. The cell was the ASTM compliant 1 L Metrohm Autolab corrosion cell.

Before the measurement, the disk was polished with sandpaper and rinsed with isopropyl alcohol, to ensure a clean surface. The solution was deaerated by bubbling nitrogen gas for one hour, in order to minimize the amount of oxygen dissolved in the solution. The disk was immersed in the solution 30 minutes before the experiment, during nitrogen bubbling. Thanks to the two-ways gas inlet of the Metrohm Autolab 1 L corrosion cell, it was possible to maintain a nitrogen blanket above the solution during the measurement, in order to obstruct the oxygen diffusion from the atmosphere into the solution.

An Autolab PGSTAT302N was used for the measurement. The procedure and the data treatment were done with the NOVA 2 software.

The ASTM G5 is based on a voltage scan starting from the corrosion potential E_{corr}, (the open circuit potential OCP), to 1.60 V vs. saturated calomel electrode (SCE) [1]. Referred to the Ag/AgCl 3 mol/L KCl reference electrode in use, the end potential was 1.630 V.

The data was plotted in accordance with ASTM Practice G3.[1]

Results and discussion

, The plot of potential vs. logarithm of the current density is shown in Figure 1.

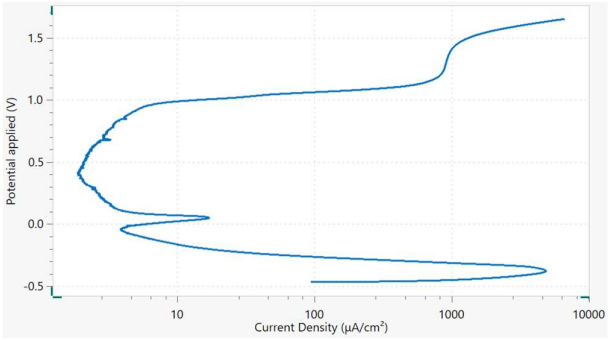

Figure 1 - Potential vs. current density (logarithmic scale) for a 1 cm^2 stainless steel sample in 0.5 mol/L H_2SO_4 solution

The common features related to the oxidation process of stainless steel in acidic solution are visible in this plot. For clarity, the specific regions are highlighted in Figure 2.

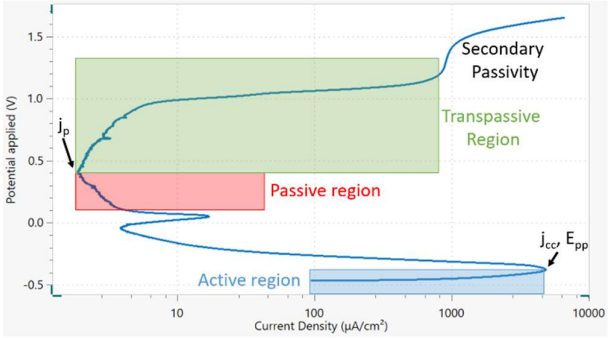

Figure 2 – same as Figure 1 but the active region (in blue), the passive region (in red), the transpassive region (in green) and the secondary passivity are highlighted.

From bottom to top, the active region of oxidation is present (blue). Here oxidation occurs, until the primary passivation potential E_{pp} is met, which corresponds to a critical current density j_{cc}.

For potential values higher than E_{pp}, the current density decreases, due to a possible formation of a passive layer. After a small peak, the current density does not change substantially from its passive current density value j_p with increasing the potential. This is the passive region (red). At

potentials higher than the value where j_p occurs, the current density increases again, due to breakage of the passive layer. This is the transpassive region (green).

Further on, another passivating region occurs, named secondary passivity, where again the current does not change much with increasing the potential. After the secondary passivity, oxygen evolution can occur, not shown in the Figure.[2]

Conclusions

The ASTM standard G5 for testing the corrosion of stainless steel 430 in sulfuric acid solution has been implemented in a NOVA procedure and the experiment performed with a PGSTAT302N and a 1 L corrosion cell. The results show the common features of stainless steel oxidation, passivation, transpassivation and secondary passivation.

References

[1] ASTM G5 - Standard Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements. Developed by Subcommittee G01.11, book of standards volume 03.02.

[2] ASTM G3 - Standard Practice for Conventions Applicable to Electrochemical Measurements in Corrosion Testing. Developed by Subcommittee G01.11, book of standards volume 03.02.

Date

March, 2019 AN-COR-012

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**.