

EIS on Curved Electrodes

Introduction

This Technical Note concerns electrochemical impedance spectroscopy (EIS), and assumes that you have read and understand the material covered in the Application Note "[Basics of Electrochemical Impedance Spectroscopy.](#)"

The purpose of this Technical Note is to show that you can do EIS using Gamry Instruments' potentiostats not only on flat samples in electrochemical cells, but also on curved parts not immersed in a liquid medium.

Experiment

Curved, machined pieces of steel (the samples) were tested under the following conditions:

In a two-electrode EIS experiment, the sample acted as the Working Electrode and Working Sense Electrode. A graphite rod was used as Counter Electrode and Reference Electrode. (See Fig. 1.)

To provide an ionic path for the measurements, a moist paper towel was placed between the sample and the graphite rod. The paper towel was wrapped around the rod and secured in place using a polymer O-ring. The paper towel was thick enough to prevent a short circuit between the sample and rod. The aqueous solution in the towel was 1% weight/weight KNO_3 dissolved in de-ionized water. (See Fig. 2.)

Various samples, including passivated and non-passivated surfaces, were tested. Each passivated sample was passivated via a different method. All data were recorded using a Gamry Instruments 600+™ potentiostat and Framework™ software, in potentiostatic mode. DC potential was set to open-circuit potential.



Figure 1. Overall EIS testing stage, showing curved metal sample (sitting on top of butyl-rubber stopper), with graphite rod pressing upon the sample.

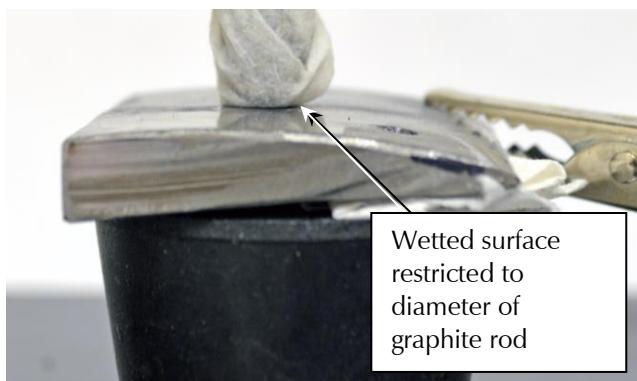


Figure 2. Close-up photograph of active sample area. A $\text{KNO}_3(\text{aq})$ solution wets a paper towel on the end of the graphite rod. The towel is held in place using an O-ring.

Data Analysis

Data were analyzed using Gamry Instruments' Echem Analyst™ software. The following equivalent circuit (Fig. 3) was used to model the data:

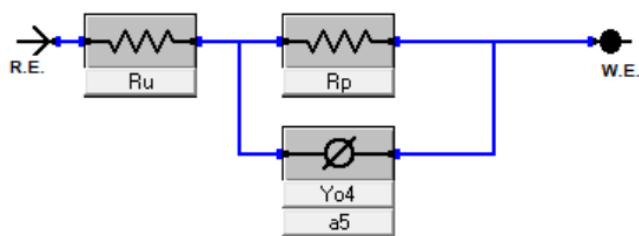


Figure 3. Screenshot from Echem Analyst software, showing equivalent circuit used to model the EIS data. Y_04 corresponds to a constant-phase element with coefficient a_5 . R_p is the polarization resistance, and R_u is the uncompensated resistance. For more details on these circuit elements, see our Application Note "[Basics of Electrochemical Impedance Spectroscopy.](#)"

Results are given in Figure 4.

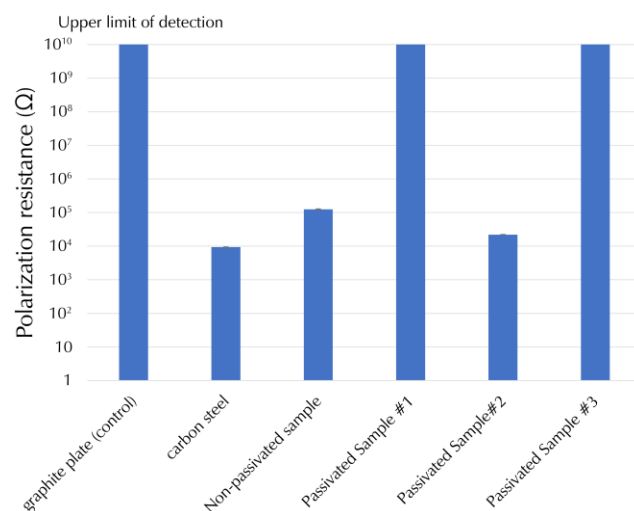


Figure 4. Polarization resistance R_p taken from fitting the data for various samples to the equivalent circuit in Figure 3. Error bars represent the fitting error. Maximum R_p detectable was 10 G Ω .

Polarization resistance is inversely proportional to the corrosion rate. Therefore, a higher polarization resistance means a lower corrosion rate.

The purpose of this Technical Note is to suggest how to make measurements on curved surfaces or in applications where it is not possible to immerse the entire sample in a solution. The method emphasizes quick-testing over a complex, rigorous EIS setup. Thus, it suffers from several drawbacks including the lack of a standard reference electrode to isolate the counter electrode impedance. However, some users may find this method useful when making routine EIS measurements on replicate samples where detecting a change in impedance is desired.

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