Calculating corrosion rates using LPR and EIS

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Outline

• Summary of Linear Polarization Resistance (LPR) and Electrochemical Impedance Spectroscopy (EIS)
• Demonstration of performing LPR and EIS experiments
• How to calculate the corrosion rate from the data
Linear Polarization Resistance

- LPR is an “active” technique
- It is fast and relatively simple
- Must have stable Open Circuit Potential (OCP)
- Scan over a small potential range relative to OCP to maintain linearity
- Slope of Voltage (V) vs. Current (I) is polarization resistance (Rp)
Linear Polarization Resistance

1. Monitor OCP and allow to stabilize.

2. Apply initial Voltage that is 10-15 mV negative of OCP.

3. Scan at a slow scan rate (~0.125 mV/s) to a final voltage that is 10-15 mV positive of OCP and monitor the current.

4. Plot Voltage (Y-axis) versus Current (X-axis), and measure the slope which is \( R_p \) (\( V=IR \))

5. Convert \( R_p \) to \( i_{corr} \) using the Stern-Geary Equation.

6. Convert \( i_{corr} \) to Corrosion Rate.
Calculation of $I_{\text{CORR}}$ from $R_P$

Stern-Geary Equation

$$\Delta V/\Delta i = R_P = \beta_a\beta_c/2.3 \ i_{\text{CORR}} (\beta_a + \beta_c)$$

Where

$R_P = $ Slope at the origin of the Polarization Resistance Plot in ohms or ohms-cm$^2$

$i_{\text{CORR}} = $ Corrosion Current, Amperes or Amperes/cm$^2$.

$\beta_a, \beta_c = $ Tafel Constants from a Tafel Curve, volts/decade of current.

Note: The area of the electrode must be taken into account
Calculation of Corrosion Rate from $I_{\text{CORR}}$

- Corrosion Rate (mpy) = 0.13 $I_{\text{corr}}$ (EW)/d

Where

- mpy is milli-inches per year
- EW is the equivalent weight
- d is the density in g/cm$^3$
Electrochemical Impedance Spectroscopy

- EIS is measured by applying an AC potential and then measuring the resulting current and phase angle through the cell.
- Measured using a small excitation signal so that the cell's response is pseudo-linear, \( \sim 10 \) mV.
Electrochemical Impedance Spectroscopy

- Polarization resistance can be found through the resulting data using equivalent circuit modeling