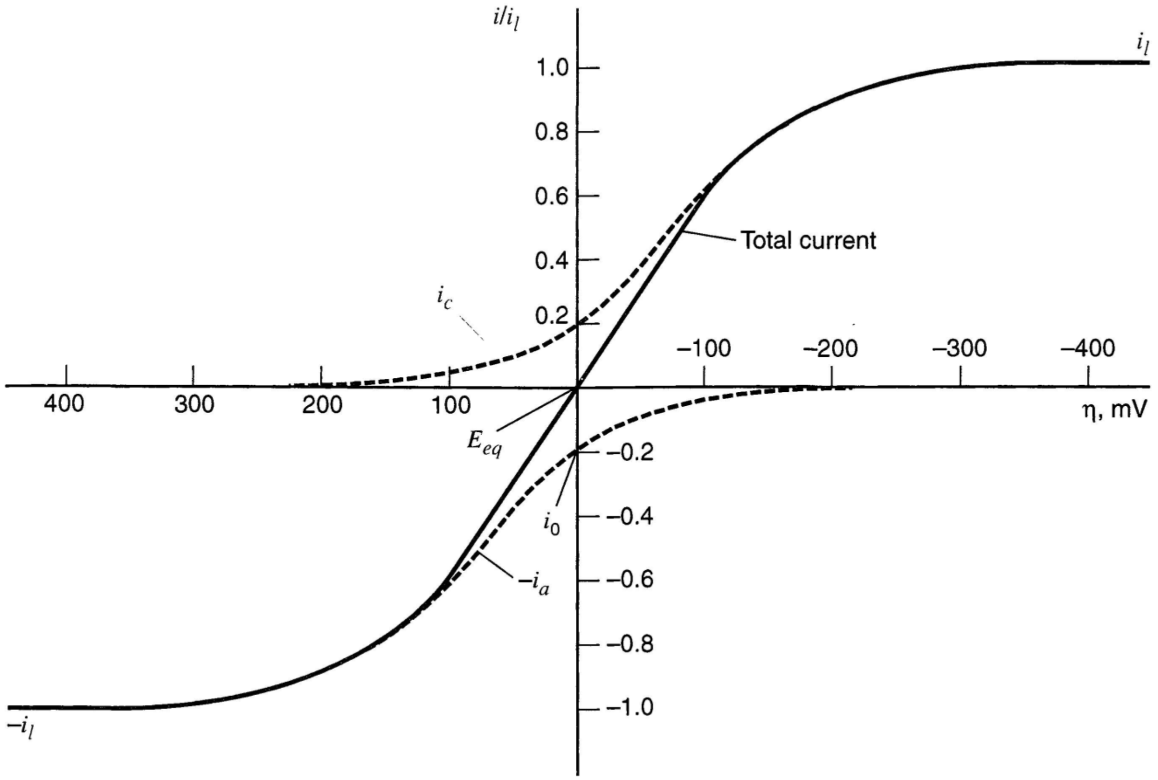
Derivation of Tafel Equation

For a reversible reaction on surface: $Ox + e \leftrightarrow Red \;\; E^o$



$$\boxed{i = FAk^0 \left[C_O(0,t)e^{-\alpha f(E - E^{0'})} - C_R(0,t)e^{(1-\alpha)f(E - E^{0'})} \right]}$$

$f = F/RT$, C_o, C_R = concentration
α = transfer coefficient

When $|\eta|$ >= 100 mV, the back-reaction is insignificant and can be neglected i = 0, when $FAk^0C_O(0,t)e^{-\alpha f(E_{eq}-E^{0'})} = FAk^0C_R(0,t)e^{(1-\alpha)f(E_{eq}-E^{0'})}$ = i_o

i_o = exchange current

Assuming the surface concentration is close to bulk concentration

$$\boxed{i = i_0\left[e^{-\alpha f\eta} - e^{(1-\alpha)f\eta}\right]}$$

When the absolute value of η >= 100 mV, then the back reaction is negligible, we have

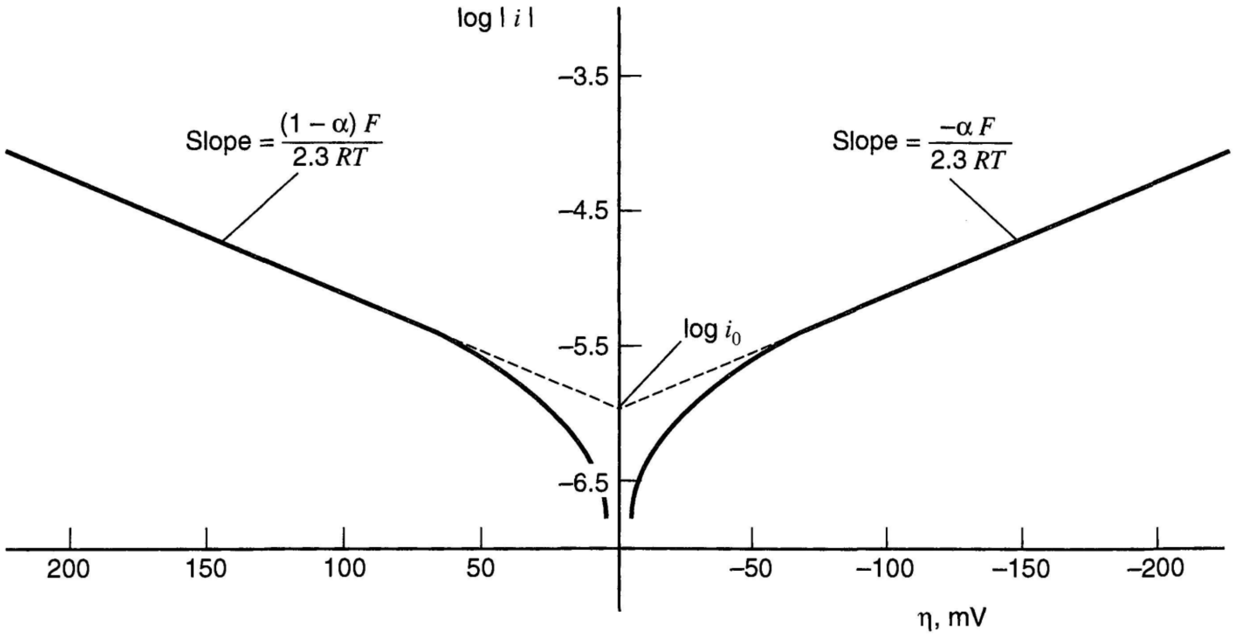
$i = i_o \exp(-\alpha F\eta/RT)$ or $$\boxed{\eta = \frac{RT}{\alpha F}\ln i_0 - \frac{RT}{\alpha F}\ln i}$$

This is the deduction of Tafel equation: η = a + blogi

b = -(2.3RT/αF), when α = 0.5, b = 118 at r.t. b is called Tafel slope

Both exchange current and Tafel slope are obtained from the plot of η vs. log i

Plot of log i and overpotential can give i_o and Tafel slope



In electrochemistry, we use current density to describe the reaction rate
J = i/A, i is the current, and A is the surface area.