Overpotential phenomenon in hydrogen production by water electrolysis with AC impedance method

Researchers: Wu, Ching-Hung
Advisor: Hourng, Lih-Wu

Abstract

In order to let an environment and the technology could be sustainable development, it becomes pressing issue to use the renewable and clean energy. Therefore, the topic for this study is hydrogen production by water electrolysis.

Motivation

Electrochemical Impedance Spectroscopy (EIS) is commonly used to investigate the fuel cell. EIS only can use in the small voltage. But it never use EIS and the curve fitting to research a reaction of water electrolysis.

Principle

Hydrogen Production By Water Electrolysis

\[ \text{H}_2\text{O} \rightarrow \text{H}_2 + \frac{1}{2}\text{O}_2 \] (In the neutral and alkaline electrolyte)

Equivalent Circuit

\[ \begin{align*}
Q &: \text{Constant phase element} \\
R_{\Omega} &: \text{Ohmic loss} \\
R_A \cdot R_C &: \text{Anode - Cathode charge transfer loss}
\end{align*} \]

Over Potential Phenomenon

\[ E = \eta_{\Omega} + \eta_A + \eta_C \]

E : an actual electrolysis
\( \eta \) : polarization overpotential
In order to maintain the current, the increased potential is called the polarization overpotential.
\( \eta_{\Omega} \) : resistance polarization overpotential
An electrode's surface often forms a thin film, which results in increased resistance of an electrode.
\( \eta_A \) : activation polarization overpotential
Electrode and electrolyte interface will generate potential barrier. Therefore, needs to increase an energy to the ions.
\( \eta_C \) : concentration polarization overpotential
The chemical reaction causes the electrolyte to form the concentration difference.

AC Impedance

Utilizing Nyquist plot to analyst ac impedance

\[ \text{Scanning Frequency} : 1000~5000\text{HZ} \]
The more round shape Nyquist curve is, the concentration polarization is more obvious. So the conductive degree is worse.

Nyquist Plot of AC Impedance

Methods

Nyquist Plot of AC Impedance

The more round shape Nyquist curve is, the concentration polarization is more obvious. So the conductive degree is worse.

Electrolysis Efficiency : 10wt% > 20wt% > 30wt% > 40wt%

Error Amount of Curve Fitting

Equivalent circuit calculate the ac impedance error amount between the actual value and the theoretical value.

Prove

Potentialstat input 1~5 voltage for each electrolyte and test the current of change. Then observe the slope near the 2V.

Conclusions

Overpotential phenomenon in hydrogen production by water electrolysis with AC impedance method conforms the actual condition.

Future works

Utilize the best parameters (ex: voltage, electrodes space) to increase electrolysis efficiency.
Reduced the complexity of the parameters when measuring impedance with large voltage.