101年大學部國際交流甄選專題成果展

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

21

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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

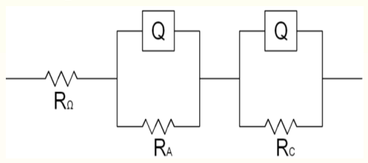
Electrochemical Impedance Spectroscopy(EIS) is commonly used to investigate the fuel cell. EIS only can use in the small voltage. But it never use EIS and the curve fitting to research a reaction of water electrolysis.

Principle

Hydrogen Production By Water Electrolysis

$H_2O \rightarrow H_2 + \frac{1}{2}O_2$ (In the neutral and alkaline electrolyte)

Equivalent Circuit



Q：Constant phase element R_Ω：Ohmic loss
R_A、R_C：Anode、Cathode charge transfer loss

Fig1.

Over Potential Phenomenon $E = \eta_\Omega + \eta_A + \eta_C$

E : an actual electrolysis

η：polarization overpotential

In order to maintain the current, the increased potential is called the polarization overpotential.

η_Ω : resistance polarization overpotential

An electrode's surface often forms a thin film, which results in increased resistance of an electrode.

η_A：activation polarization overpotential

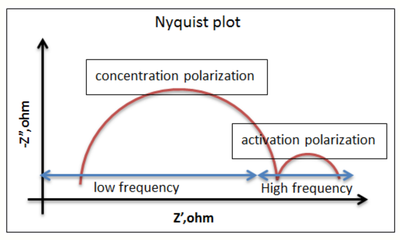
Electrode and electrolyte interface will generate potential barrier. Therefore, needs to increase an energy to the ions.

η_C：concentration polarization overpotential

The chemical reaction causes the electrolyte to form the concentration difference.

AC Impedance

Utilizing Nyquist plot to analyst ac impedance

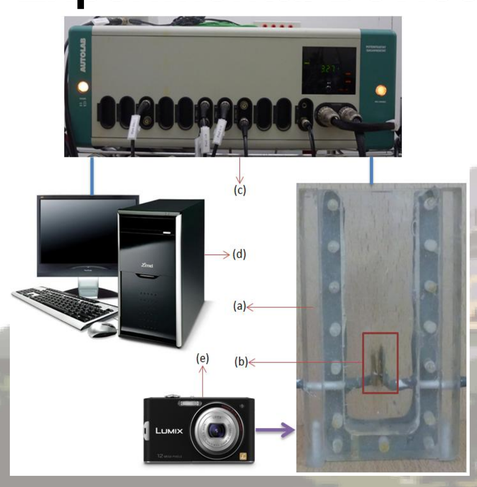


Scanning Frequency ：1000~5000HZ
The more round shape Nyguist curve is, the concentration polarization is more obvious. So the conductive degree is worse.

Fig2.

Resistance polarization is related to the electrolyte and electrode. This study did not change the materials. Thus, there is no discussion on the impact of the impedance.

Experimental Device



Experimental Procedures

Utilize Frequency Response Analysis (FRA) to represent an AC impedance's Nyquist Plot. Then utilize a software ZSimp Win to represent an error amount between the actual measured values and the theoretical value of an equivalent circuit in a curve fitting. Find the most suitable electrolyte concentration. Prove the result with potentialstat.

Fig3.

(a)electrolytic cell (30×15×100mm) (b)electrode(Ni, 10×10mm)
(c) Potentiostat：AUTOLAB PGSTAT302N (d)computer (e)camera

Methods

Nyquist Plot of AC Impedance

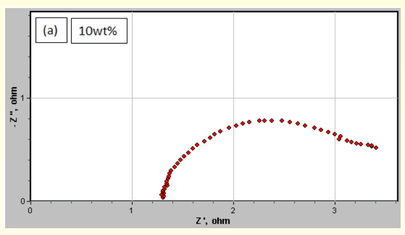


Fig4.

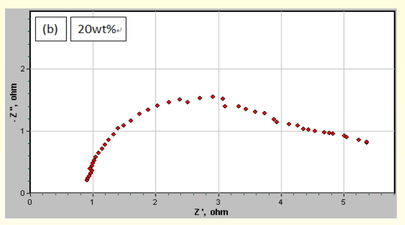


Fig5.

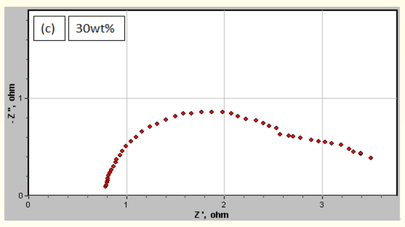


Fig6.

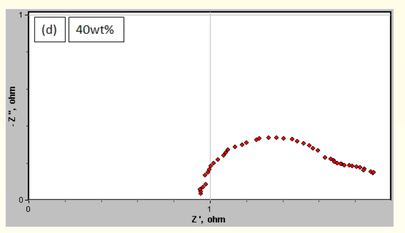


Fig7.

The more round shape Nyguist 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.

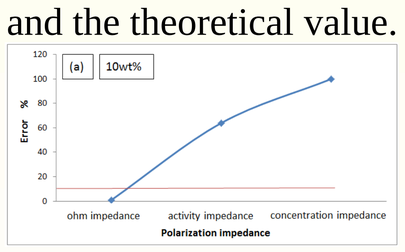


Fig8.

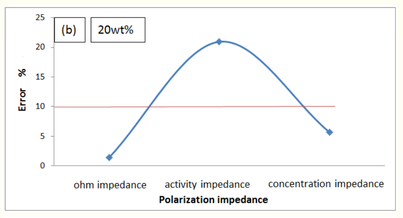


Fig9.

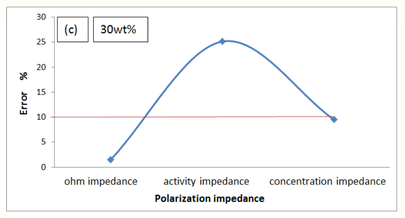


Fig10.

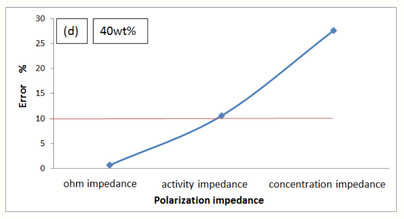


Fig11.

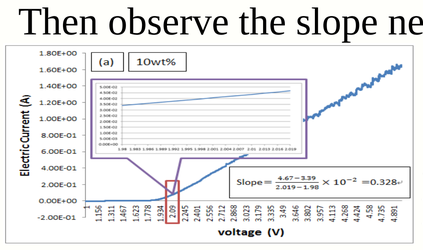
If lower 10% error amount is an acceptable amount, 20%wt and 30%wt conforms anticipation.

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

The best electrolysis efficiency is 20wt%~30%wt of the above two results because the error amount of 10%wt is too large.

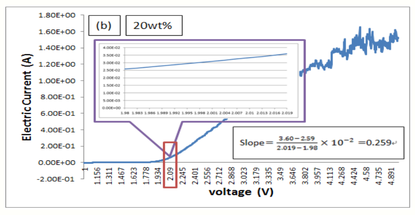
Prove

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



Slope：0.328

Fig12.



Slope：0.259

Fig13.

Slope：0.367

Fig14.

Slope：0.472

Fig15.

A higher slope value indicates the more unstable concentration change. Proving that an ideal electrolysis efficiency is 20wt%~30%wt .

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.