# Electrochemical Polarization Behavior of Dissolved Hydrogen and Hydrogen Peroxide at a Pt Electrode in 573K Boric Acid Solution

*Ke Chon. Choi, Jei- Won Yeon, and Won-Ho Kim*
*Nuclear Chemistry Research Division, Korea Atomic Energy Research Institute,*
*150 Deokjin-dong, Youseong-gu, Daejeon, 305-353*
*nkcchoi@kaeri.re.kr*

## 1. Introduction

Recently, extensive study was carried out on the chemical control of coolant for the reduction of radioactivity, extension of life cycle, and operation of optimization nuclear reactor [1]. Various chemical additives for controlling water chemical cause to corrode and generate a particle according to progressing nuclear reaction at reactor [2]. Also, generation of particles changes into a physical chemistry characteristic according to operation condition of a nuclear reactor. It raises a radioactivity or accumulation at a cooling system. Specially, the chemical characteristics of coolant such as solubility of metal oxides and redox potential at high temperature and high pressure condition depends on the concentration of dissolved hydrogen and hydrogen peroxide[3]. We examined the effect of hydrogen and hydrogen peroxide on the trend of electrochemical polarization in boric acid solution. [4].

## 2. Experiments and Results

### 2.1 Equipments for electrochemical measurement

The equipments for electrochemical measurements are installed as shown in Figure 1. This equipment consists of autoclave, electrochemical measurement, hydrogen injection, hydrogen detection, and sampling part, respectively. Electrochemical measurement system consist of working electrode (Pt rod), counter electrode(Pt wire), and external reference (Ag/AgCl) electrode. And potentiostat (model PAR-273, Eg &G co., ) was used for electrochemistry polarization measurement. All electrochemical experiments were carried out at 573 K and 150 bar.

### 2.2 Experiments

In a 1.3L autoclave containing 1.0L of 2,000 ug/mL boric acid, add 10~15ug/mL of LiOH. And Ar. Gas purged for 30 min. in order to remove dissolved oxygen. And $H_2$ was filled with pressure of 1~6 bar. Dissolved hydrogen was measured after heating temperature of autoclave autoclave with 280~300℃. The hydrogen measuring instrument was used, and inner dissolved

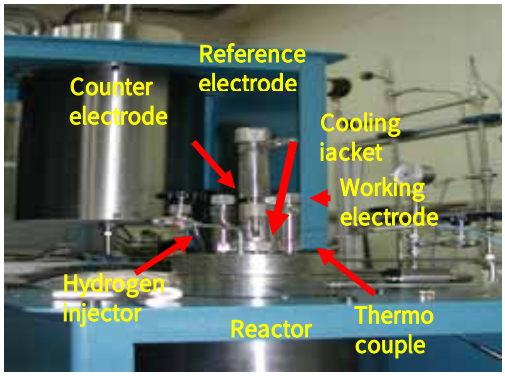


Fig. 1.Equipment of electrochemical autoclave system

hydrogen concentration of autoclave was measured after having let temperature rise by bubbling and 280~300 degrees for 30 minutes by pressure( 1~6 bar) in hydrogen gas injection port of autoclave.

### 2.3 Effect of LiOH on electrochemical polarization in boric acid solution.

As the dissociation constant of boric acid is very low from room temperature to normal operation temperature of reactor, the boric acid solution itself did not affect at Pt electrode. On the other hand, Figure 1 shows, a small amount of LiOH changes the electrochemical behavior of the test solution. The hydrogen and oxygen gas evolution reactions which involve in hydrogen ion were mainly affect. Also, Figure 2 shows that the reaction rate of hydrogen evolution, reduction of dissolved oxygen, and oxidation of $H_2O$ are increased as raising solution temperature. From above results, we analyze that the high reaction rates at high temperature comes from increase of dissociation of water, diffusivity change of ions and molecules, and decrease of activation energy of each electrochemical reaction.

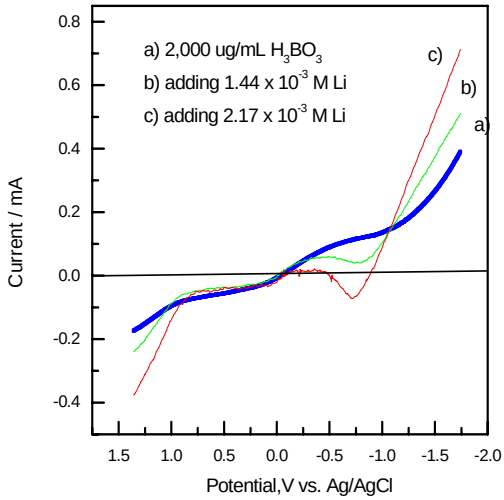


Fig. 2 Linear sweep voltammograms at a Pt electrode in various boric acid solutions

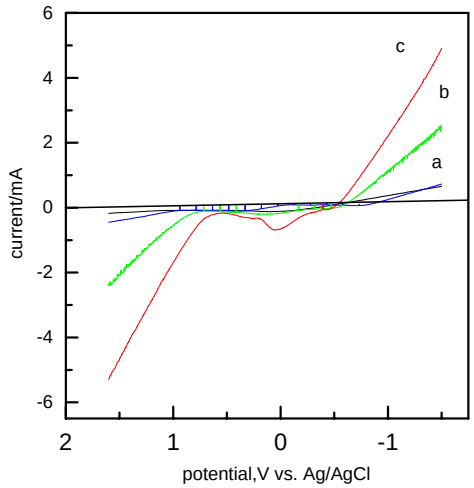


Fig. 3 Linear sweep voltammograms at a Pt electrode in various temperature in 7.24 x$10^{-4}$ M $H_3BO_3$ a);46.6, b);155.9, c)256.7+(o)C respectively

2.4 Effect of $H_2O_2$ on electrochemical polarization in boric acid solution

The effect of $H_2O_2$ on the electrochemical polarization behavior was carried out. The polarization curves were shifted to positive direction (anodically) as adding H2O2. This phenomenon is similar with that dissolve oxygen because $H_2O_2$ decomposes into oxygen gas at high temperature solution.

2.5 Effect of $H_2$ on electrochemical polarization in boric acid solution

The effect of $H_2$ on the electrochemical polarization behavior was carried out. The polarization curves were shifted to negative direction (cathodically) as adding $H_2$. The oxidation rate of dissolved hydrogen is increased as adding $H_2$ gas into the solution

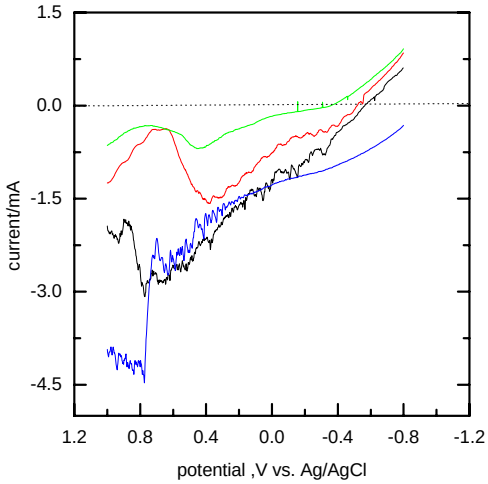


Fig. 4 . Linear sweep voltammograms at a Pt electrode in various dissolved hydrogen concentration in 1200 ppm $H_3BO_3$ 3.0 ppm Li at high temperature,
green; 0.09 $H_2$ cc/kg at 288 °C, red; 37.8 $H_2$ cc/kg at 286 °C,
black; 59.7 $H_2$ cc/kg at 283 °C, blue; 74.4$H_2$ cc/kg at 283 °C,

## 3. Conclusion

The concentration of boric acid did not affect the electrochemical behavior at a Pt electrode. On the other hand, a small amount of LiOH changes the electrochemical behavior of the test solution. The polarization curves were shifted to positive direction (anodically) as adding $H_2O_2$, and to negative direction (cathodically) as adding $H_2$.

## REFERENCE

[1] Chien C. Lin, F. R. Smith, R. L. Cowan, " Effects of hydrogen water chemistry on radiation field buildup in BWRs", Nuclear Engineering and Design, 166, pp. 31-36, 1996.
[2] M. Domae, N. Chitose, Z. Zuo, Y. Katsumura, *Radiation Physics and Chemistry*, 56, pp. 15-322, 1999.
[3] P. J. Karditas, S, M. Ali, D. Wan, "Copper corrosion and activation in water cooling loops under fusion irradiation conditions", Journal of Nuclear Materials, 283, pp.1346-1350, 2000.
[4] B.Pastina,J.Isabey and B.Hickel, "The influence of water chemistry on the radiolysis of the primary coolant water in PWR reactors",Journal of Nuclear Materials , 264,pp. 309-318, 1999.