The effects of hydrogen on reactivation of iron in alkaline solutions
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The reactivating effect of hydrogen on iron in alkaline solutions (pH 8.4~13) was investigated with a Devanathan dual cell at room temperature by measuring open circuit potential (OCP), electrochemical impedance spectroscopy (EIS) and potentiodynamic anodic polarization curves. All the potentials were measured and quoted against a saturated calomel electrode (SCE). Two test procedures TA and TB were used in the measurements. Test TA measurements were conducted for non-charged specimens after OCPs were stable. Test TB measurements were conducted for hydrogen-charged specimens after OCPs were stable. Hydrogen-charging was performed by adding sulfuric acid with thiourea in the cathodic cell of the Devanathan dual cell. Electrochemical measurements were performed in the anodic cell of the Devanathan cell.

Hydrogen in iron decreased the open circuit potential dramatically and changed the open circuit state from passivation to active dissolution state in 0.1 mol/L NaHCO₃ solution, Fig. 1. It took a longer time for the hydrogen in iron to cause the shift of open circuit potential state from passivation to active dissolution in 1.0 mol/L NaHCO₃ solution than that in 0.1 mol/L NaHCO₃ solution. Hydrogen in iron increased the anodic current density in the potential range before the transpassivation potential and resulted in two anodic current peaks for iron in 0.1 mol/L NaHCO₃ solution, Fig. 2. Hydrogen in iron drastically decreased the electrochemical impedance at the open circuit potential, Fig. 3. Hydrogen in iron caused a shift of OCP from about -0.38 V in the presence of hydrogen to about -0.58 V for iron in 0.1 mol/L NaOH (pH=13) solution, Fig. 4. A similar effect of hydrogen on iron on OCP of iron in 0.5 mol/L Na₂CO₃ solution (pH=11) was observed. Hydrogen in iron increased the anodic current density in the potential range before the transpassivation potential for iron in 0.1 mol/L NaOH solution, Fig. 5. No anodic current peak was observed in the hydrogen-charged iron. Results show that hydrogen in iron causes the instability of passive films and enhance the anodic dissolution rate for iron in alkaline solutions. The effects of hydrogen in iron on open circuit states and anodic processes are strongly dependent on the solution pH and the concentration of electrochemically active species.

Fig. 1 Open circuit potential versus time for iron in 0.1 mol/L NaHCO₃ solution at room temperature and the effect of hydrogen permeation.

Fig. 2 Anodic polarization curves for non-charged (TA) and hydrogen-charged (TB) iron specimens in 0.1 mol/L NaHCO₃ solution at room temperature.

Fig. 3 EIS diagrams for non-charged (TA) and hydrogen-charged (TB) iron specimens in 0.1 mol/L NaHCO₃ solution at room temperature under open circuit potentials.

Fig. 4 Open circuit potential versus time for iron in 1.0 mol/L NaOH solution at room temperature and the effect of hydrogen permeation.

Fig. 5 Anodic polarization curves for non-charged (TA) and hydrogen-charged (TB) iron specimens in 0.1 mol/L NaOH solutions at room temperature.