HYDROGEN PROMOTED PITTING SUSCEPTIBILITY OF IRON

J.G. Yu[a], J.L. Luo[a] and P.R. Norton[b]
[a]Department of Chemical and Materials Engineering,
University of Alberta,
Edmonton, Alberta, Canada T6G 2G6
[b]Department of Chemistry, University of Western Ontario,
London, Ontario, Canada N6A 5B7

Application of cathodic protection, electroplating, pickling and other processes causes the ingress of hydrogen into metals. Hydrogen entering a metal can affect its corrosion behavior. One of the most detrimental effects of hydrogen on the corrosion behavior of metallic materials is that hydrogen promotes the pitting susceptibility of alloys. The results obtained so far are mainly based on polarization curve and pitting induction time measurements and no detail information on the effects of hydrogen on the initiation, growth and repassivation of pitting was reported. The objective of this work is to investigate the effect of hydrogen on the initiation, growth and repassivation of pitting of iron by electrochemical noise measurements and scanning reference electrode technique (SRET).

Fig.1 shows a typical time record of current fluctuations for the uncharged specimen and specimen charged at 0.05 mA/cm^2 in a 0.3M H_3BO_3+0.075M $Na_2B_4O_7{\cdot}10H_2O$ solution containing 0.1M chloride ions after the specimens were immersed in the solution for 3100 seconds. It can be seen that for the uncharged specimen, the current almost showed no fluctuations. While for the charged specimen, hydrogen strongly increased the number of current fluctuations, indicating that hydrogen strongly promotes the generation of metastable pitting events of iron, which is proportional to the probability of generation of a stable pit [1]. Fig.2 shows the variation of the values of roll off slope in power density spectrum (PSD) plots of current noises of uncharged and charged iron with immersion time. It is believed that the higher the value of the roll off slope, the faster rate of repassivation of a pit [2]. It can be seen from this figure that as immersion time increases, the values of the roll off slope of PSDs for the uncharged specimen increase again after experiencing a minimum value, indicating that the repassivation rate of a pit on an uncharged specimen increases with immersion time. By contrast, the values of the roll off slope of PSDs for the charged specimen decrease with immersion time, indicating that the repassivation rate of a pit on a charge specimen decreases with immersion time. Fig.3 shows the 2D potential maps on the surfaces of unhcharged and charged iron obtained by SRET. It can be seen that at same condition, pits, which are represented by green color, occur on the charged iron, while not on uncharged iron, confirming that hydrogen promoted the initiation of pitting of iron.

In conclusion, hydrogen strongly promoted the initiation of pitting of iron and decreases the repassivation rate of pits.

[1] D. E. Williams, C. Westcott and M. Fleischmann, J. Electrochem. Soc. **132**, 1796(1985).
[2] M. Kendig, S. Jeanjaquet and M. Mahoney, "Electrochemical Noise Analysis of the Corrosion of Aluminum Alloys andComposites," Paper 383, CORROSION 88, NACE, St. Louis, MO, 1988.

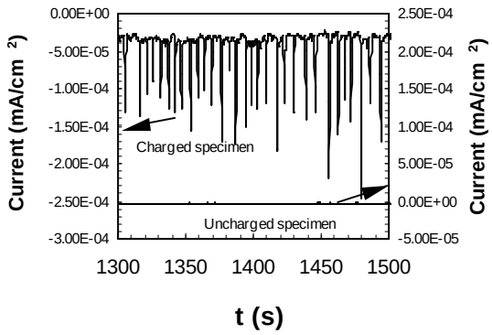


Fig.1 The records of current fluctuations of uncharged and charged iron after the specimens were immersed for 3100 seconds.

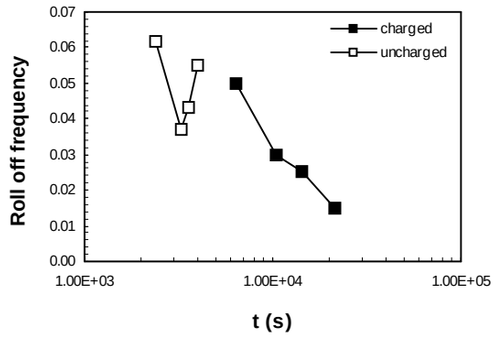
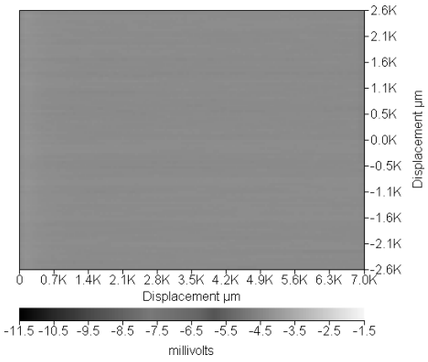
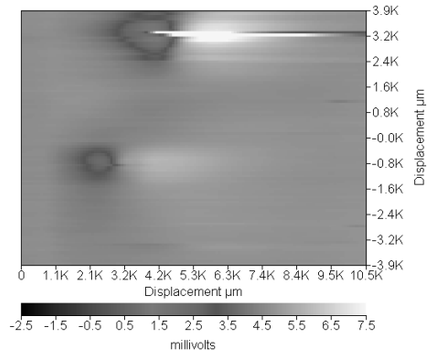


Fig.2 The variation of the values of the roll off slope in the PSDs of current noises of the uncharged and charged iron with immersion time.



(a)



(b)

Fig.3 2D potential maps on the surfaces of uncharged and charged iron in a 20mM H_3BO_3+5mM $Na_2B_4O_7{\cdot}10H_2O$+0.5mM Cl^- polarized at 80mV for 4 minutes (vs. SCE). (a) uncharged; (b) charged iron.