# Change of Chemical Species with Progress of Crevice Corrosion

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**INTRODUCTION**: One of the most destructive modes for corrosion of metals is localized corrosion. Crevice corrosion is a form of localized corrosion. Due to its narrow region, the exchange of solution between the interior of crevice and the bulk is difficult. In this work, we present a simulation research based on a two-dimensional model of crevice corrosion of stainless steel SUS304 in NaCl solution. The equilibrium reactions occurred in the solution are combined with the electrochemical reactions on the surface of SUS304. The concentration distributions of various ions, oxygen, and hydrogen in the crevice are obtained and the pH value in the crevice is presented and evaluated.

**COMPUTATIONAL METHODS**: The model of a crevice in 2D used in this work is shown in Fig. 1. The crevice is formed by two SUS304 sheets. The half width of crevice is 10 µm. 0.1 M NaCl is considered. The chemical species taken into account in the solution are $Fe^{2+}$, $Ni^{2+}$, $Cr^{3+}$, $H^+$, $OH^-$, $FeOH^+$, $CrOH^{2+}$, $FeCl^+$, $CrCl^{2+}$, $CrClOH^+$, $Na^+$, $Cl^-$, $O_2$, $H_2$, $H_2O$. The initial pH is 6. The dissolution reactions of metal and cathodic reduction reactions on SUS304 are involved and the equilibrium reactions in the solution are

$$H_2O \leftrightarrow OH^- + H^+$$

$$Cr^{3+} + H_2O \leftrightarrow CrOH^{2+} + H^+ \qquad Cr^{3+} + Cl^- \leftrightarrow CrCl^{2+}$$

$$Fe^{2+} + H_2O \leftrightarrow FeOH^+ + H^+ \qquad Fe^{2+} + Cl^- \leftrightarrow FeCl^+$$

$$CrCl^{2+} + H_2O \leftrightarrow CrClOH^+ + H^+$$

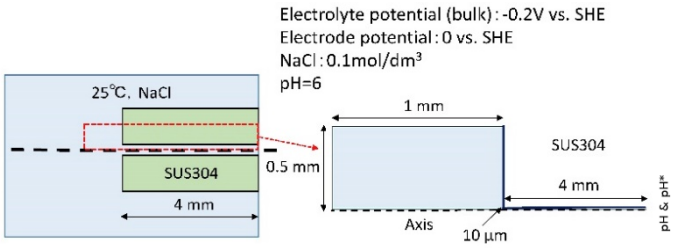


**Figure 1**. Model of crevice corrosion

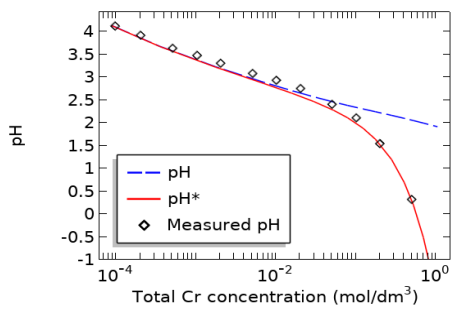


**Figure 2**. pH and its modified value pH* by activity coefficient of $H^+$

The reversible reactions in the Chemistry interface of COMSOL are used to solve the equilibrium reactions in solution, and are coupled with the Tertiary Current Distribution, Nernst-Planck interface.

**RESULTS**: A benchmark simulation is performed to confirm the equilibrium reactions in solution. The obtained pH* shown in Fig. 2 are in good agreement with the measured data. The simulation results for change of chemical species in solution with progress of crevice corrosion are shown in Figs. 3-5.

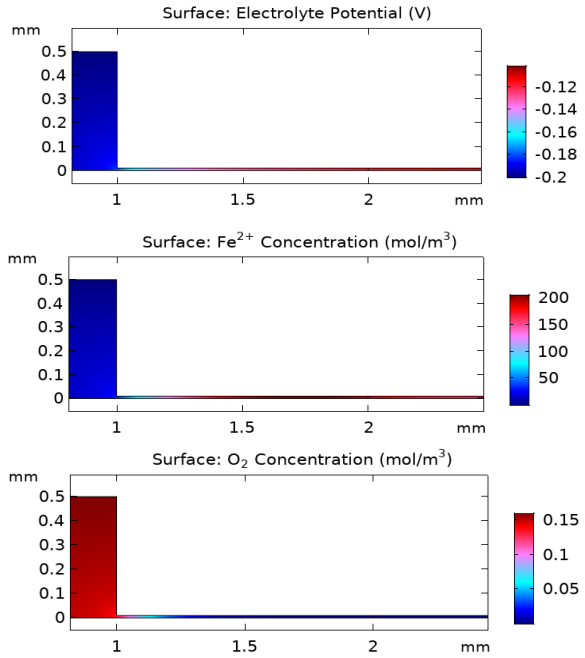


**Figure 3**. Distributions of electrolyte potential, $Fe^{2+}$ ion and $O_2$

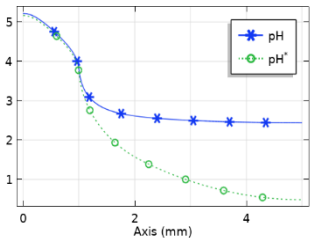


**Figure 4**. pH and pH* in the middle of a crevice

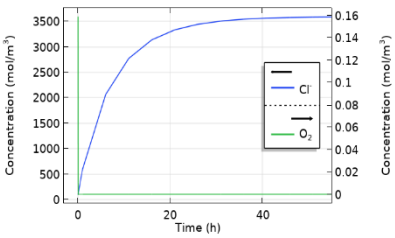


**Figure 5**. Time variation of of $Cl^-$ ion and $O_2$

**CONCLUSIONS**: In this paper, the simulation of crevice corrosion of SUS304 stainless steel in NaCl solution was performed using COMSOL. The change in solution properties due to crevice corrosion was obtained and analyzed.

**REFERENCES**:

1. J.S. Newman and K.E. Thomas-Alyea: *Electrochemical Systems*, 3rd ed., John Wiley & Sons, Inc., Hoboken, NJ (2004)
2. Y. Fukaya and T. Shinohara, *66th Symposium of Materials and Environments in Japan*, B-107 (2019) [in Japanese]