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Effect of Metal Cations on Passive Film Structure Formed on Iron

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Summary

It was reported that the corrosion rate of mild steel was varied with metal cations in model fresh water and the possible reason was the incorporation of metal cations into passive film to improve the corrosion resistance of the film. The hardness of metal cations was applied to quantitative evaluation for metal cations effect on corrosion rate of steel, however, corrosion rate in solutions with some metal cations did not follow the hardness of metal cations. It is still not clear more hard metal actions can suppress the corrosion rate of steels. A corrosion inhibitor is often used to decrease corrosion of steels, however, metal cation effect on inhibition ability of corrosion inhibitor is also not clarify. In this study, the effects of metal cations on corrosion of iron in model fresh water and inhibition ability of gluconates for fresh water corrosion of iron enhanced by metal cations were investigated. Immersion test, electrochemical impedance spectroscopy (EIS) and surface observation and analysis with SEM and X-ray photoelectron spectroscope (XPS) were carried out.

The solutions used to investigate the influence of metal cations on corrosion behavior were five different metal cations containing solutions as 1 mol m^{-3} NaCl, 0.5 mol m^{-3} $MgCl_2$, 0.5 mol m^{-3} $ZnCl_2$, 0.33 mol $m^{-3}AlCl_3$, and 1 mol m^{-3} NaC with 0.5 mol m^{-3} $ZrCl_2$. 1 mol m^{-3} $NaC_6H_{11}O_7$ (sodium gluconate) or 0.5 mol m^{-3} $C_{12}H_{22}O_{14}$ Zn (zinc gluconate) were used for investigation of inhibition ability of gluconates for fresh water corrosion of mild steel enhanced by metal cations.

From SEM observation, a clear grain boundary was observed on specimens immersed in solutions with Na^+, Mg^{2+} and Zr^{4+}, while not intense corroded surface was observed on the specimens immersed in solutions with Zn^{2+} and Al^{3+}. The corrosion resistance obtained from EIS results was increased with increasing the value of corrosion inhibitory effect of cation, which is calculated by metal cation hardness and volume ratio of molar volume between the hydroxide of cations and passive film.

The corrosion rate of specimen inhibited as gluconate ions in the solution, and it suppressed more coexistence of Zn^{2+}. Based on EIS and XPS results, the increasing corrosion inhibition ability of gluconate ions by Zn^{2+} may be attributed to reduce the defects in the protective film of gluconates on steel.