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# Effect of Metal Cations on Passive Film Structure and Corrosion Protection Property

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Summary

It is well known that concentration of chloride ions and pH are most important factor for evaluate the corrosion behavior of steels and metals in aqueous environments. Therefore, many researches have been carried out focused on these values. There are reports that metal cations in fresh water also showed important role in corrosion of metals. However, there has been no study, in which the quantitative effects of metal cations on corrosion of mild steel in aqueous systems were investigated. In this study, the effects of metal cations on corrosion of mild steel in model fresh water were investigated by immersion tests, and surface observation and analysis with scanning electron microscope (SEM) and X-ray photoelectron spectroscope (XPS). The hardness of cations, *X,* was used to quantitative evaluation for metal cations effect on corrosion rate of steel. The *X* was calculated by using $[X^0_M + (\sum I_n)^{1/2}]^2 / 10$, where $X^0_M$ is the electronegativity of metal atoms and $\Sigma I_n$ is the total ionized potential from neutral metal atoms to a given oxidized state, n, The solutions used were four different metal cations containing solutions as 1 mol $m^{-3}$ NaCl, 0.5 mol $m^{-3}$ $MgCl_2$, 0.5 mol $m^{-3}$ $ZnCl_2$, and 0.33 mol $m^{-3}AlCl_3$. After immersion tests, there are many brown corrosion products in solutions with $Na^+$ and $Mg^{2+}$, and the amounts of those corrosion products in the solutions with $Zn^{2+}$ and $Al^{3+}$ were decreased in comparison with those in solutions with $Na^+$ and $Mg^{2+}$. From SEM observation, there is clear intergranular corrosion after immersion in solutions with $Na^+$ and $Mg^{2+}$, and corrosion behaviours of the grains were different, while the specimen after immersion in the solution with $Zn^{2+}$showed many pits, and the intergranular corrosion is not as obvious at that on specimens after immersion in solutions with $Na^+$ and $Mg^{2+}$. Some pits with no intergranular corrosion were observed on the specimen after immersion in the solution with $Al^{3+}$. The corrosion rate of mild steel decreased with increase in the hardness of cations, *X*, in the solutions. XPS analysis showed that hard metal cations were incorporated in the passive films of the mild steel, and hydroxides of metal cations were formed on the mild steel after immersion for a short time. It was suggested that the incorporation of metal cations into passive film was the main reason for increasing corrosion resistance by hard metal cations.