

Influence of metal cations on corrosion and hydrogen absorption of steel under simulated marine atmospheric condition

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Abstract Sea salt is a well-known corrosion inducer for steel structures in marine environments. With the wide employment of Al-Mg-Zn-containing coatings as an anti-corrosion method, the anodic dissolution during salt-induced corrosion will introduce several metal cations such as Na⁺, Mg²⁺, Zn²⁺, and Al³⁺ to the steel surface, which is considered to influence the corrosion kinetics and some side reactions like hydrogen evolution. Therefore, this study aims to investigate the effect of such metal cations on the corrosion and hydrogen absorption processes of steel in simulated marine atmospheric environments.

High-strength steel samples were subjected to a cyclic wet-dry environment with an initial deposition of 10mM NaCl, 5mM MgCl₂, 5mM ZnCl₂, and 3.3mM AlCl₃ solutions respectively. The samples were attached to an electrochemical cell for the detection of diffused hydrogen during the corrosion process. The in-situ changes in the corrosion morphology and hydrogen permeation of samples were recorded. The surface and cross-section analysis of the samples were conducted using SEM-EDS, XPS, and AES.

The results show that the metal cations of the deposited salts have a significant influence on the corrosion morphology and hydrogen absorption behavior of steel. Zn²⁺ and Al³⁺ exhibited an inhibition effect on the rust formation under droplets. The amount of permeated hydrogen through the steel under salt deposits increases in the order of NaCl, MgCl₂, ZnCl₂, and AlCl₃. The difference in the hydrogen absorption under salt deposits was related to the varying deliquescence relative humidity of different salts. The high deliquescent property of the deposited salt increases the time of wetness for corrosion and hydrogen entry into steel. The variation in the hardness of metal cations is suggested to be a potential method to explain the effect of salts on the corrosion morphology and hydrogen absorption during the atmospheric corrosion of steels.

Keywords Marine atmospheric corrosion; Hydrogen absorption; Metal cation