

Effect of Phosphate-containing Primer on Sacrificial Corrosion Protection of 55 mass% Al-Zn Layer on Steel

Junichiro Ogawa¹, Izumi Muto¹, Kensei Yuasa²,
Yoshio Kimata², Yu Sugawara¹, and Nobuyoshi Hara¹
¹Department of Materials Science, Tohoku University
6-6-02, Aramaki, Aoba-ku, Sendai 980-0867, Japan
²Nippon Steel & Sumitomo Metal Corporation
20-1, Shintomi, Futtsu, Japan

Prepainted galvalume (55 mass% Al-Zn coated) steel sheets have excellent corrosion resistance in atmospheric environments and are widely used as architectural materials. Prepainted steels suffer from the cut edge corrosion, known as “blister” or “edge creep”. Strontium chromate (SrCrO_4) is one of the most effective inhibitors, which are added in the primer of paint layers. Extensive studies have been, however, devoted to finding alternative inhibitors, because of the toxicity of hexavalent chromium. Phosphate is expected to be an alternative inhibitor. We focused on the electrochemical properties of phosphate in corrosion protection of the cut edges of prepainted 55 mass% Al-Zn coated steels.

Prepainted 55 mass% Al-Zn coated steels (substrate steel : 0.45 mm thick) with and without phosphate were used. The thickness of top coating, primer, and 55 mass% Al-Zn layers were 10, 5, and 15 μm , respectively. The prepainted steels were embedded in a resin to expose the cut edge. To simulate marine atmospheric environments, cyclic wet-dry corrosion tests were performed. The chloride ion deposition on the cut edges was set at 10 g m^{-2} by controlling the concentration and volume of synthetic seawater. Polarization measurements for the 55 mass% Al-Zn and steel substrate were carried out in diluted synthetic seawater (Cl^- :500 ppm) with and without 350 ppm Na_2HPO_4 . The distributions of Fe^{2+} , Zn^{2+} and O_2 on the cut edges were examined in diluted synthetic seawater (Cl^- :500 ppm) by scanning electrochemical microscopy (SECM). The tip potential of Fe^{2+} oxidation was 0.6 V (vs. Ag/AgCl, 3.33M KCl), and the oxidation potentials of Zn^{2+} and O_2 were -1.15 and -0.7 V, respectively.

From the cyclic corrosion tests, phosphate in the primer was found to inhibit the white rust generation on the cut edge of the prepainted 55 mass% Al-Zn coated steel. In the polarization measurements (Fig. 1), it was confirmed that the Na_2HPO_4 addition inhibits the Zn dissolution reaction and the oxygen reduction reaction the 55 mass% Al-Zn layer. The Oxygen reduction reaction (ORR) on the steel substrate was also suppressed by the phosphate addition.

Figure 2 shows the effect of phosphate on Zn dissolution from the 55 mass% Al-Zn layer under the open circuit condition. It is clear that the phosphate in the primer decreases the dissolution rate of Zn. Figure 3 compares the SECM tip current distributions of O_2 reduction on the specimen with and without phosphate. On the specimen with phosphate, O_2 was depleted in an area away from the Al-Zn layer, marked by arrows in Fig. 3(a). On the other hand, O_2 was reduced at an area close to the Al-Zn layer for the specimen without phosphate. It appears that the phosphate in the primer suppresses the ORR near the 55 mass% Al-Zn layer, which is associated with the effective sacrificial protection behavior on the cut edges of the prepainted galvalume steels.

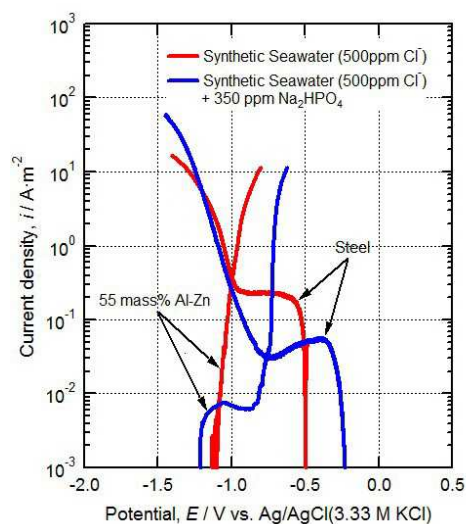


Fig. 1 Polarization curves of steel and 55%Al-Zn in diluted synthetic seawater containing 500 ppm Cl^- and 350 ppm Na_2HPO_4

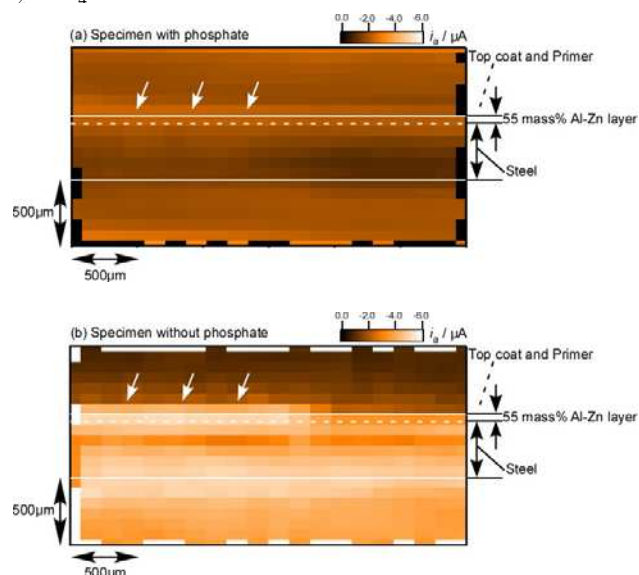


Fig. 2 SECM tip current distribution of Zn^{2+} reduction reaction for cut edges of specimen (a) with and (b) without phosphate. Tip potential is -1.15V.

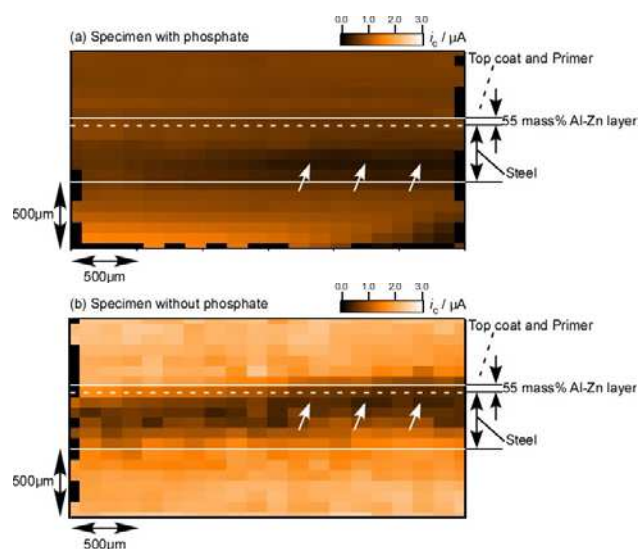


Fig. 3 SECM tip current distribution of O_2 reduction reaction for cut edges of specimen (a) with and (b) without phosphate. Tip potential is -0.7V.