

## INITIAL CORROSION CHARACTERISTICS OF ENAMEL COATED CARBON STEEL IN HOT TAP WATER

© 2022 Ronghai Xu<sup>a</sup>, Sensen Xin<sup>a</sup>, Qingzhao Ni<sup>a</sup>, Hongtao Zeng<sup>a</sup>, and Moucheng Li<sup>a</sup> \*

<sup>a</sup> Institute of Materials, School of Materials Science and Engineering, Shanghai University, Shanghai, 200072 China  
\*e-mail: mouchengli@shu.edu.cn

Received July 23, 2019; revised April 27, 2020; accepted May 15, 2020

The corrosion behavior of enamel coating on carbon steel was investigated in the tap water at 80°C (i.e., the simulated electric hot water tank environments) by using scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and electrochemical measurement techniques. The through porosity of enamel coating is about 0.0076%, simply measured by in-situ electrochemical impedance spectroscopy (EIS) in the dilute sulfuric acid solution. The through defects facilitate the solution penetration in the coating and the formation of occluded corrosion cell on the steel substrate in the hot tap water. The occluded zones have low resistances to both ionic transport and active corrosion. The steady steel corrosion is controlled by the oxygen diffusion via the enamel coating defects, which is accompanied by the transport of anion ions and corrosion products.

**Keywords:** enamel coating, corrosion, through porosity, inner tank of electric water heater, hot tap water, EIS

**DOI:** 10.31857/S0424857022030124

### CONCLUSIONS

The through porosity and initial corrosion behavior of enamel coating on carbon steel are characterized by EIS in the dilute sulfuric acid and synthetic tap water at 80°C, respectively. The main conclusions can be drawn as follows:

Many defects such as various pores form in the enamel coating on the inner tank of electric water heater. The coating porosity induced by the through defects can be evaluated simply by using *in-situ* EIS technique in the hot solution 0.1 mol L<sup>-1</sup> H<sub>2</sub>SO<sub>4</sub> + 0.2 mol L<sup>-1</sup> NaCl. The porosity value stabilizes at about 0.0076% within 24 to 48 h, but will change in the evolution processes of capillary penetration, corrosion propagation and corrosion products accumulation.

The through coating defects provide the fast pathways for solution penetration and the locations for

forming the occluded corrosion cell on the underlying steel. After about 442 h of immersion in the hot tap water, the steel corrosion under the enamel coating defects may attain a steady state and is controlled by the oxygen diffusion. In the corrosion process, the anion ions such as Cl<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, and HCO<sub>3</sub><sup>-</sup> migrate into the occluded pits, whereas the corrosion products loosely deposit in the pits and gradually transfer to the enamel coating surface via the through defects. As a result, the occluded zones show very low resistances to both ionic transport and active corrosion. But the enamel coating generates no galvanic couple effect on the localized corrosion due to its insulating properties.

This is an excerpt of the article “Initial Corrosion Characteristics of Enamel Coated Carbon Steel in Hot Tap Water.” Full text of the paper is published in Russian J. Electrochemistry, 2021, vol. 57, p. 636.