APT study of corrosion products on a weathering steel exposed in SO_2-rich industrial atmosphere

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Abstract Corrosion products provide key information for understanding corrosion mechanism. To date, element distribution in weathering steel (WS) rust layer (RL) at the nanoscale remains inadequately investigated. It is generally believed that the enhanced corrosion resistance of WS is due to the nanoscale grains tightly packed in the inner RL. However, there is a lack of investigation to address the elements distribution in the inner RL at nanoscale. In recent years, some researchers have proposed that the significant corrosion resistance of WS in SO_2-polluted industrial atmosphere can be attributed to the formation of non-cracked, uniform, and protective amorphous hydroxylated iron oxide. Dillmann [1] and Morcillo [2] pointed out that an unsolved issue regarding atmospheric corrosion of WS is related to the amorphous substances. This may be because the detection and study of amorphous substances are extremely challenging. This study investigates the microstructural and compositional evolution of corrosion products formed on WS under exposure to SO_2-rich atmosphere. Notably, the extremely unique RL feature on the WS after 12 months of exposure in SO_2-rich industrial atmosphere was found, consisting of an outer RL, an inner RL with ultrafine grains, and a transition layer with amorphous. The Atom probe tomography (APT) analysis revealed, for the first time at the atomic scale, that the amorphous transition layer enriched with Ni, while the ultrafine grains in the inner RL layer contained Cr-rich and Si-rich particles. The interaction between the SO_2-rich atmosphere and the alloying elements in the steel plays a significant role in the formation and stability of the corrosion layers. The results provide insights into the corrosion mechanisms of WS in harsh industrial environments, contributing to the development of more durable and corrosion-resistant materials.

Keywords *Weathering steels, element distribution, corrosion products, SO_2-rich environment, APT*

Reference

[1] P. Dillmann, F. Mazaudier, S. Hoerle. Corrosion Science 46 (2004) 1401-1429.

[2] M. Morcillo, I. Díaz, B. Chico, H. Cano, D. de la Fuente. Corrosion Science 83 (2014) 6-31.