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Unravelling the Mechanism of Filiform Corrosion on Painted Carbon Steel

Michele Fedel, Stefano Rossi, Luca Benedetti, Flavio Deflorian and Andrea Cristoforetti

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Abstract

Filiform corrosion (FFC) is recognized as a special case of an oxygen-concentration cell that forms on a metal beneath a paint layer, exhibiting a distinctive thread-like appearance. Under the paint, it is possible to distinguish the leading head from the growing tail thanks to the marked colour gradient. In fact, the front part of the head appears green coloured (in correspondence of the so called "green rust") and tail brown coloured (in correspondence of the corrosion product containing Fe_2O_3 , FeOOH , $\text{Fe}(\text{OH})_3$). FFC occurs on low carbon steel more frequently than expected, requiring only a relative humidity between 65% - 95% and mild chloride contamination to be triggered.

This study introduces a novel methodology for investigating the mechanism of filiform corrosion in organic coated steel. The approach leverages the scanning vibrating electrode technique (SVET) and potentiometric scanning electrochemical microscope (SECM), also known as micropotentiometry. By creating artificial defects in specific locations of the filaments under the coating, the electrochemical activity beneath the coating is evaluated by mapping ionic current densities. In addition, antimony tips are utilized to probe the metal-paint interface, enabling the assessment of local pH changes associated with various corrosion reactions.

Through in-situ measurements of electrochemical activity governing FFC on organic coated steel, this study precisely identifies the anodic and cathodic regions and determines the pH values at the metal-paint interface along the filament. Consequently, a more comprehensive depiction of the FFC mechanism emerges, addressing gaps in existing literature and validating hypotheses proposed over decades of research. Beyond insights into FFC, this investigation serves as a pioneering application of established techniques to explore corrosion mechanisms in coated metals.

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