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Electrochemical Impedance Spectroscopy Assessment of Zinc Rich Primer Performance and Its Degradation Processes

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The anti-corrosive coating technology applied on steel structures in high corrosivity heavy-duty industry is still dominated by coating systems with zinc rich primer providing galvanic protection. Traditional evaluation methods for coating performance tests e.g. rust creep evaluation according to ISO 12944-9 are in general time consuming, they are destructive and subjectively based. In addition to this, they lack any assessment of the initial coating condition and the degradation process before any visible signs by the naked eye. This research aims to propose non-destructive evaluation methods which can optimise the assessment process for anti-corrosive coating evaluation and further predict the coating performance by mathematical modelling.

Currently, in this research, Electrochemical Impedance Spectroscopy (EIS) is applied as one of the non-destructive evaluation methods to study coating degradation processes of a commercial zinc rich epoxy primer (with a zinc content $\leq 75\%$) system exposed to salt spray (ISO 9227) chamber with 5wt.% of NaCl at 35°C. By analysing the data collected from the EIS experiment at different exposure time in the salt spray, the degradation process of the zinc-rich epoxy coating combined with open circuit potential (OCP) stabilization, three distinct degradation phases were identified: 1) Penetration of aggressive species into the coating film, 2) galvanic protection by zinc, followed by 3) iron corrosion. Furthermore, the water uptake tendency profile in the coating film can be estimated based on the capacitive evolution determined from the measured impedance data. In the case with an increased dry film thickness of the zinc rich primer from 50 μm to 80 μm more than a four-fold increase in galvanic protection duration is observed. This work uses the accelerated salt spray experiment in combination with non-destructive EIS assessment technique which is able to follow zinc rich primer performance from the beginning. This assessment method can contribute a faster evaluation and development of new coating recipes thereby save time and resources.

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