Electrochemical Testing Coupled with Real Time Imaging, a New Tool for Assessment of Anticorrosion Performance

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There is general agreement that industrial accelerated corrosion tests such as the Salt Spray Test (SST) and others are not always adequate to evaluate real-life performance. The source of concern is that accelerated tests rely on a particularly aggressive environment to reduce the time to failure during the test. Thus, corrosion mechanisms that would never be present under real-life conditions could be initiated and cause failure. Further, the output of such tests is generally expressed as pass (no corrosion) or reject (unacceptable corrosion) and little or no information on the time-evolution of the corrosion process is obtained.

On the other hand, electrochemical tests, more common in Academia, rely on measuring the response due to an externally applied voltage or current of an immersed corroding surface. They are fast and provide fundamental information on the corrosion processes but it is debated if they are representative of the real-life behaviour due to the electrical perturbation of the corroding surface. Further, they are generally not standardized and difficult to standardize, since the optimum test parameters depend on the material-environment combination; optimization and interpretation requires a well-trained operator.

Electrochemical Noise Analysis is unique among the electrochemical techniques because it does not require the application of a probing signal to the corroding surfaces. In practice, two nominally identical specimens are immersed in a test solution and electrically connected through an external circuit. As a result of corrosion on the surfaces, current and potential fluctuations are detected and recorded. The theory behind the interpretation of the electrochemical noise signal is well established, but relatively complex. For this reason, a specific software package has been recently developed and distributed online (Figure 1). The package requires minimal user knowledge and estimates the electrode impedance (inversely proportional to corrosion rate), the average charge (proportional to volume of material corroded) and the frequency of corrosion events, as a function of exposure time.

Data obtained from electrochemical noise measurements are intrinsically representative of a freely corroding system because no probing signal is applied. Further, the use of ready-made software to extract relevant, time-dependent, corrosion-related quantities, does not require detailed understanding of the underlying theory (Figure 2).

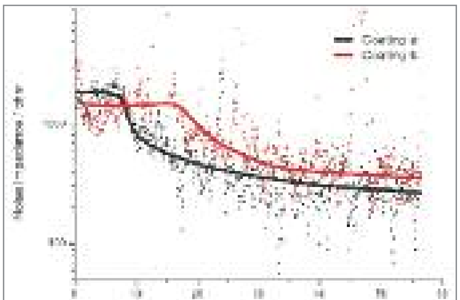

Fig 2.

For these reasons, the method is an ideal candidate to be standardised (by standardising the test environment) and to provide simultaneously quantitative fundamental and practical performance data.

Being an immersion test, as an added benefit, the surface of the specimens can be imaged in real time and image-analysis techniques and accelerated footages can be used to highlight the details of corrosion initiation and propagation (Figure 3). The two combined approaches, automated electrochemical noise analysis and associated surface imaging, provide a new intuitive, low cost and robust tool for the comparative evaluation of the corrosion performance of protective treatments, inhibitors and paints. A stand alone cabinet, capable of simultaneously recording and analysing the electrochemical noise signal and the surface appearance of the corroding specimens has been recently developed. Direct comparison of images and time-lapse video allows a rapid identification of the best candidate treatment between competing solutions. Consideration of the values of low-frequency noise impedance provides quantitative estimation of the anticorrosion performance. Once finalized and commercially available, it will be a powerful tool for both fundamental and applied corrosion studies, enabling reliable information to be obtained without requiring a highly trained operator.

Fig. 2 Time evolution of the low-frequency noise impedance for two ZE41 magnesium alloy specimens supporting oxide coatings obtained by plasma electrolytic oxidation; a) 10 mA and b) 20 mA for 10 min, corrosive electrolyte: 3.5% NaCl. High values of impedance indicate low corrosion rates, low values of impedance indicate that corrosion is propagating, rapid decrease indicates corrosion initiation. Lines are intended as a guide to the eye.

Fig 1.

Fig. 1 Homepage of the website where the electrochemical noise analysis software can be downloaded (www.electrochemicalnoise.com)

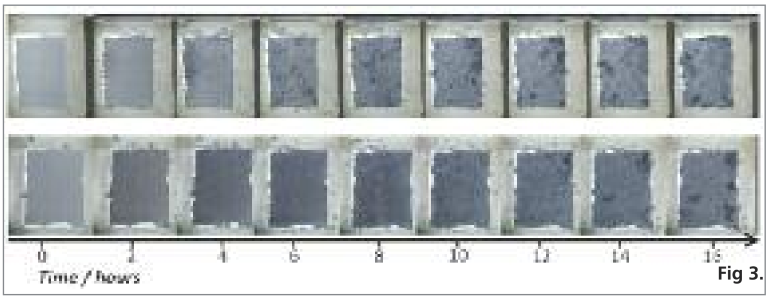

Fig 3.

Fig. 3 Images acquired during corrosion of ZE41 magnesium alloy supporting oxide coatings obtained by plasma electrolytic oxidation; a) 10 mA and b) 20 mA for 10 min. Red arrows indicate the first sign of coating failure (4 hr and 12 hr respectively), corrosive electrolyte: 3.5% NaCl.

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