An Approach To Verify The Water Transport Model In Organic Coatings

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Abstract

The protection of metal surfaces against corrosion is commonly achieved by the application of organic coatings. A dedicated evaluation of those coating systems is strictly necessary before putting them into service. While outdoor test programs are time intensive and accelerated corrosion tests can lead to limited service performance information, predictive modelling of the durability and lifetime of organic coated metals under long-term environmental corrosion can provide a promising alternative.

Predictive modelling of organic coated systems aims to develop a computational tool consisting of all subsystems (metal, coating and electrolyte) and all corrosion phenomena (transport in the coating, electrochemistry and coating delamination) able to predict the long-term corrosion behaviour. The key aspect of this approach is the experimental validation of the developed corrosion model at all stages.

In this study, we focus on modelling water transport through a coating, and optimization and verification of the model using experimentally obtained impedance data. The coatings used for the study are simplified commercial thermal and UV curables. The mathematical model used is a one-dimensional (1D) model developed in COMSOL multiphysics, using the transport of diluted species module (tds), taking into account transport through the coating (diffusion). A distinction is made between free and bound water inside the coating while considering water adsorption and desorption reactions. Using input data on transport properties of the coating, obtained by gravimetry, Fourier transform infrared spectroscopy (FTIR) and thermal analysis measurements, e.g. differential scanning calorimetry (DSC) and isothermal microcalorimetry (IMC), a parameter optimization study is performed to determine the transport parameters describing this phenomenon used in the model. Then the output of the model, i.e. water concentration as a function of coating thickness and exposure time, is used to generate virtual impedance plots which can be evaluated against experimentally collected impedance data, through post-processing of the results in COMSOL multiphysics.

To provide the experimental impedance data, odd random phase multisine EIS (ORP-EIS) measurements are performed. Non-stationary behaviour is deconvoluted using the instantaneous impedance technique described in [1] to record water uptake from the initial stages. Additionally, the coating capacitance, determined using complex capacitance, is monitored over time to extract information on water uptake and diffusion coefficients.

[1] T. Breugelmans et al., Electrochimica Acta 79 (2012) 375-382.