BARRIER PROPERTY DETERMINATION AND LIFETIME PREDICTION BY ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY OF A HIGH PERFORMANCE ORGANIC COATING

DETERMINACIÓN DE PROPIEDADES BARRERA Y DE PREDICCIÓN DE TIEMPO DE VIDA POR ESPECTROSCOPÍA DE IMPEDANCIA ELECTROQUÍMICA DE UN RECUBRIMIENTO ORGÁNICO DE ALTO RENDIMIENTO

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ABSTRACT: The anticorrosion performance of an Epoxy-Mastic organic coating was evaluated during continuous immersion in saline solution using electrochemical impedance spectroscopy (EIS). The typical parameters of pore resistance and charge transfer resistance were determined employing an equivalent electric circuit. Constant phase elements (CPE) were used in order to determine fraction of water absorbed, mass diffusion, solubility and the swelling coefficients, as well as to predict the failure times of the coating. The results found by EIS measurements match very well with the high resistance to deterioration exhibited by the coating. It was also found that the excellent protection performance of the coating was mainly due to low water solubility and low permeability.

Key words: Organic coatings, electrochemical impedance spectroscopy, water diffusion, delaminated area, failure time prediction.

RESUMEN: El desempeño anticorrosivo de un recubrimiento orgánico tipo Epoxy-Mastic fue evaluado en condiciones de inmersión continua en solución salina usando espectroscopía de impedancia electroquímica (EIS). Se determinaron los parámetros típicos como la resistencia de poro y resistencia a la transferencia de carga usando un circuito eléctrico equivalente. Se usaron elementos de fase constante (CPE) para determinar la fracción de agua absorbida, coeficientes de difusión de masa, solubilidad y coeficientes de hinchamiento, así como también para predecir los tiempos de falla de dicho recubrimiento. Los resultados hallados por medio de medidas EIS concuerdan con la alta resistencia al deterioro que exhibe el recubrimiento. El excelente desempeño protector es debido principalmente a la baja solubilidad y permeabilidad de agua.

Palabras clave: Recubrimientos anticorrosivos, espectroscopía de impedancia electroquímica, difusión de agua, área delaminada, predicción de tiempos de falla.

1. INTRODUCTION

Two decades ago Haruyama [1] proposed a method for calculating the deterioration of organic coatings exposed to a corrosive environment using the equivalent circuit shown in Fig. 1. Haruyama's methodology phenomenologically explains the processes that occur inside organic coatings when they are exposed to an electrolyte and when there are minor defects or imperfections, such as small pores, in the coating. The Randles circuit (Fig. 2) has been used extensively to evaluate organic coatings that exhibit highly capacitive behavior or to evaluate pore-free coatings. However, the Randles circuit becomes useless after a few hours of continuous immersion because new time constants in the impedance spectra may appear. A complete description of each of the passive elements making up the two circuits shown in Fig. 1 and 2 can be found in numerous sources [2, 3]. The coating resistance (R_C) is closely related to the state of the coating, its additives or pigments, porosity and type of resin. The coating capacitance (C_C) is associated with the amount of water absorbed during the initial stages of exposure to the electrolyte [4]. The charge transfer resistance (R_{ct})