A Modelling Approach For The Study Of AA2024 Corrosion Protection Using Active Coatings Utilization

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Abstract

Nowadays, aluminum alloys (AAs) are among the main structural materials in the aeronautical industry. While representing high-strength and low-weight properties, their microstructural complexity and heterogeneity makes them highly susceptible to local corrosion. Therefore, a corrosion protective coating is required. Chromium based inhibitors incorporated in organic coatings have proven to be an efficient solution to protect Aluminum structures. However, given their toxicity and carcinogenic nature, their usage is currently subject to strict international environmental, health and safety legislation. Therefore, the need exists for a safe and efficient replacement. In recent years, multiple corrosion inhibitor types have been shown to be highly promising. Further studies are essential to understand an inhibitor's function and limits in different environments. However, such extensive experiments would be time consuming. Alternatively, modelling has been considered to offer a faster path for insights into an inhibitor's efficiency.

This work is a 2D model utilizing COMSOL corrosion module to simulate the function of active protective coatings. Model geometry is a defect through the protective coatings exposing the metal surface. Electrolyte varying composition as well as the expected interactions among the inhibitor and the different species within electrolyte are considered. The electrochemical reactions occurring between the inhibitor and the alloy are suggested. Their kinetic coefficients in the Butler-Volmer equation are fitted using the data obtained from linear sweep voltammetry measurements. Concentrations of the different species, as well as potential and current changes over the surface, are calculated. This model is later used as a method to predict the required initial concentration of active coating to provide protection to the aluminum surface under different scribing conditions.

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