CORROSION RESISTANCE AND THERMAL STABILITY ENHANCEMENT OF GREEN LAYERED CLAY/EPOXY COATING

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Abstract. A layered clay/epoxy coating was fabricated to investigate the effects of montmorillonite (MMT) and halloysite nanotube (HNT) loading at 0.5, 1.5, and 2.5 parts per hundred resin (phr) on the corrosion resistance and thermal stability of coated mild steel plates. The corrosion study was carried out by Electrochemical Impedance Spectroscopy (EIS) and Tafel polarization. The $|Z|_{0.1Hz}$ value, R_{ct}, and R_p of the layered/clay epoxy coatings containing 1.5 phr of HNT and MMT exhibited the best anticorrosion performance compared to other clay content levels. The $|Z|_{0.1Hz}$ value for the epoxy coating filled with 1.5 phr of MMT (M1.5) is 2.132×10^9 Ω·cm², while it is slightly higher for H1.5 coatings, i.e., 2.629×10^9 Ω·cm². Water absorption trends were consistent with EIS and Tafel polarization studies. The presence of highly compatible nanocontainers clay reduced the total free volume and promoted cross-linking, enhancing anticorrosion performance. Thermal Gravimetry Analysis (TGA) showed that a 1.5 phr loading of MMT in layered/clay epoxy coating demonstrated better thermal stability than a coating embedded with HNT. This improvement can be attributed to the barrier effect of MMT, which retards the diffusion of oxygen molecules into the coating.

Introduction

The toxicity and harmful effects of inhibitive pigments, such as zinc chromates, severely impacting the environment and human health, have sparked huge interest in developing chromate-free coatings. Many efforts have focused on replacing chromium-containing compounds with alternative ecologically benign materials such as montmorillonite (MMT) and other layered silicate minerals to minimize hazardous waste, in line with environmental regulations [1]. The use of natural fillers has gained traction in industries due to their potential to enhance properties, availability, simplicity, and cost-effectiveness. Properly designed and dispersed nanoparticle fillers, such as clay layers in a polymer matrix, have been found to improve barrier performance, mechanical properties, and thermal stability of organic coatings [2]. These enhancements also extend to better anticorrosion performance by reducing porosity and altering the diffusion path of corrosive substances, which helps maintain coating integrity and durability over time

Nanofillers like graphene and MMT, have improved the corrosion resistance and flame retardancy properties of the epoxy filled coating compared to the pristine sample [3]. Even though the comparison study regarding HNT and MMT has been previously reported [4], the effect of these two fillers (ranging from 0.5-3.0 phr) on corrosion resistance and thermal stability performance of developed layered clay/epoxy coating prepared by multi-stage approach i.e. sonication technique and mechanical agitation technique is yet to be reported. Corrosion protection behavior of epoxy filled different clay loading was monitored over 50 days of exposure to 5.0 wt. % of NaCl solution to determine the long-term durability of coating material under severe conditions. Thermal stability and morphological analysis were also conducted to gain insights into the overall impact of adding nano clay to the epoxy matrix.