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RESEARCH ARTICLE

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Synergistic enhancement: Ammonium Polyphosphate's impact on hybrid coating performance against corrosion and fire

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Abstract

This research demonstrated the impact of ammonium polyphosphate (APP) content on corrosion resistance and flame retardancy properties of hybrid graphene oxide/halloysite/intumescent flame retardant (GO-HNT-IFR) coatings. Electrochemical impedance spectroscopy studied indicates that the GO0.6-H0.3 coating exhibited superior corrosion resistance ($R_{ct} = 2.490 \times 10^9$ Ω·cm) compared with hybrid GO-HNT-IFR coatings. Tafel polarization data revealed a decrease in polarization resistance, R_p simultaneously increases the corrosion rate, R_{corr} of the epoxy coatings containing APP compare with GO0.6-H0.3 coating. Salt spray test result demonstrated that all epoxy coating filled with hybrid nanofillers maintained excellent surface integrity, preventing corrosion for up to 500 h under controlled accelerated corrosive conditions. A reasonable increment of limited oxygen index up to 12.5% was reported by the addition of 1 phr APP, indicating its best flame retardancy and thermal stability properties among coating samples. The appropriate addition of APP (1 phr) enhanced the flame retardancy and thermal stability properties of hybrid GO-HNT-IFR coatings to a certain extent but it is impaired by increasing the APP loading. Transmission electron microscopy results validated the formation of aggregation at high APP loading, consequently affecting coating performances as well as its adhesion strength.

KEYWORDS
ammonium polyphosphate, intumescent, nanoclay, synergistic

1 | INTRODUCTION

Structural steel plays a vital role in modern building construction in the oil and gases sector, where corrosion resistance and fire protection performance are the crucial safety requirements. Corrosion of steel used in buildings can lead to structural failures, posing significant safety risks.[1] Similarly, the threat of fires poses hazards to both human life and property, potentially causing deformation or failure of structures. Continuous research and development endeavors are dedicated to fire prevention and minimizing its consequences.[2,3] The materials are designed to enhance corrosion resistance and reduce heat transfer from fires to protected structures. Epoxy coatings are one of the simplest and most effective protective coatings on steel, but they have insufficient fire resistance.[4]

Some additives have been used to enhance corrosion protection[5–7] and to enhance material resistance to ignition, delaying the combustion rate, and preventing sustained burning.[8,9] Presently, the combination of various nanofillers, known as hybrid or binary systems, has emerged as a valuable approach to enhance multiple properties of epoxy coatings.[10,11] This technique leverages the advantageous characteristics of individual nanofillers, resulting in composites with multifunctionality. Xu et al.[12] revealed that the synergy between graphene and halloysites (HNTs) not only addressed the shortcomings of water-based epoxy resin coatings but also improves their corrosion resistance. Incorporating hybrid nanofillers simultaneously solves the concerns of nanofiller aggregation and weak interfacial contact.[4]

Furthermore, to enhance flame retardant (FR) properties, intumescent systems, with or without filler additions, have proven

