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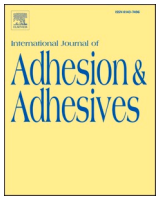

Impact of graphene nanosheets on adhesion and corrosion performance of reinforced polyurethane coating for aerospace aluminium alloy 2024-T3

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ABSTRACT

This investigation aims to create an integrated multilayer coating system for the surface of aerospace aluminium alloy 2024-T3. A solution-sonication mixing approach was applied to fabricate low-cost and high-efficiency layers. The coating system consisted of three main layers: pretreatment, green epoxy primer (GEP), and polyurethane (PU) top coating layer. To create the pretreatment layer, 50% graphene oxide (GO^{LM}dis) was functionalized using a 50% 3-aminopropyltriethoxy silane coupling agent (SCA). The PU top coating layer was grafted with 1–3% wt. of GO^{LM}dis to improve its resistance to environmental influences. Various analytical techniques such as Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), Field emission scanning electron microscopy (FESEM), and Thermogravimetric analysis (TGA) were used to evaluate the properties of the PU-GO layer. The results confirmed the graft of GO^{LM}dis onto the surface of PU, proving the existence of an interaction between the nanosheets and the polymer. The corrosion resistance performance of the multilayer coating systems was evaluated using electrochemical and adhesion tests. The 50%GO-SCA/Epoxy/2% GO-PU coating system outperforms other coating systems. It exhibited a significant improvement in the real impendence (Z_{re}) by up to 9068 % compared to other coating systems. Moreover, only 5% of the coating was removed during the adhesion analysis. The results confirm the successful incorporation of anti-corrosion graphene oxide fillers into the multilayer coating system for corrosion protection of aerospace alloy 2024-T3.

1. Introduction

Aerospace aluminium alloy 2024-T3 (AA 2024-T3) is one of aviation's most widely used alloys. This alloy has a density of 2.78 g/cc and a tensile strength of 483 MPa. Despite having these attractive properties, it is susceptible to corrosion [1]. There are several ways to prevent corrosion on AA 2024-T3. One of the most effective methods is protection using a protective organic coating (POCs) on the metal. This method is potentially fruitful for extending the material's service life with little maintenance and providing outstanding corrosion protection [2]. POCs systems may vary from direct application to the metal surface to a combination of multiple layers, namely a pre-treatment layer, a primer layer, and a top layer [3]. The pre-treatment layer provides strong adhesion and corrosion protection to the substrate and may be organic or inorganic. Silane coupling agent (SCA) coating is a typical example of this layer [4]. A primer layer is applied directly to the substrate or after a pre-treatment layer. This layer provides active protection by acting as a barrier to environmental corrosives; for instance, epoxy (EP) coating is an example of this layer. The top coat [5] is the last layer applied to the metal substrate; Therefore, it is in direct contact with the external environment. Hence, one of the requirements of the topcoat layer is to provide barrier protection for the metal substrate and resist ultraviolet radiation (UV) while also providing a pleasant appearance. Organic polyurethane (PU) formulations are a common example of top coatings because they do not degrade when exposed to sunlight [6].

In producing PUs, it is common to use polyols, diisocyanates, chain extenders, and catalysts in the reaction system. Diisocyanates [7] are an important raw material for producing PUs, as diisocyanates impart rigidity to the polymer material and come in different forms, such as cyclic aliphatic, aromatic, and aliphatic, etc. The PUs polymerization process uses polyols as a reactant [8], which can be multifunctional polyethers such as poly (propylene glycol), polycarbonate polyol, or a mixture of different polyols. Polyols impart flexibility and softness to the polymer material. Chain extenders [9] are important in shaping the polymeric material, a low molecular weight reactant that can extend the chain length in PUs-based formulations to produce elastomeric properties.

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