World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:17, No:06, 2023

Investigation of Electrochemical, Morphological, Rheological and Mechanical Properties of Nano-Layered Graphene/Zinc Nanoparticles Incorporated Cold Galvanizing Compound at Reduced Pigment Volume Concentration

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Abstract : The ultimate goal of this research was to produce a cold galvanizing compound (CGC) at reduced pigment volume concentration (PVC) to protect metallic structures from corrosion. The influence of the partial replacement of Zn dust by nano-layered graphene (NGr) and Zn metal nanoparticles on the electrochemical, morphological, rheological, and mechanical properties of CGC was investigated. EIS was used to explore the electrochemical nature of coatings. The EIS results revealed that the partial replacement of Zn by NGr and Zn nanoparticles enhanced the cathodic protection at reduced PVC (4:1) by improving the electrical contact between the Zn particles and the metal substrate. The Tafel scan was conducted to support the cathodic behaviour of the coatings. The sample formulated solely with Zn at PVC 4:1 was found to be dominated in physical barrier characteristics over cathodic protection. By increasing the concentration of NGr in the formulation, the corrosion potential shifted towards a more negative side. The coating with 1.5% NGr showed the highest galvanic action at reduced PVC. FE-SEM confirmed the interconnected network of conducting particles. The coating without NGr and Zn nanoparticles at PVC 4:1 showed significant gaps between the Zn dust particles. The novelty was evidenced when micrographs showed the consistent distribution of NGr and Zn nanoparticles all over the surface, which acted as a bridge between spherical Zn particles and provided cathodic protection at a reduced PVC. The layered structure of graphene also improved the physical shielding effect of the coatings, which limited the diffusion of electrolytes and corrosion products (oxides/hydroxides) into the coatings, which was reflected by the salt spray test. The rheological properties of coatings showed good liquid/fluid properties. All the coatings showed excellent adhesion but had different strength values. A real-time scratch resistance assessment showed all the coatings had good scratch resistance.

Keywords : protective coatings, anti-corrosion, galvanization, graphene, nanomaterials, polymers
Conference Title : ICCPAGM 2023 : International Conference on Chemistry and Practical Applications of Graphene Materials
Conference Location : London, United Kingdom
Conference Dates : June 22-23, 2023