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Evaluation of the mechanical properties and corrosion behavior of hBN-Zn composite coatings on the weathering steel

Dhurgham A. Mohsin *, Murtadha A. Jabbar, Haider M. Lieth

University of Basrah, College of Engineering, Mechanical Engineering Department, Basrah, Iraq

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ABSTRACT

Mechanical tests were conducted and analyzed to investigate the efficacy of Zinc-based coating methods enhanced with hexagonal Boron Nitride (h-BN) nanoparticles. Various methods are employed to deposit these coatings, including Zinc electroplating, Zinc hot-dip, and Zinc-rich coat (ZRC). Different parameters, such as plating time, temperature, voltage, pH, and concentrations of additives, are carefully selected during the process. The introduction of h-BN nanoparticles at varying concentrations into a Zinc- based coating significantly enhanced mechanical properties and performance measures. This improvement was achieved through the diffusion and dispersion of the nanoparticles within the coating. Furthermore, the incorporation of h-BN nanoparticles has exhibited notable enhancements in corrosion resistance when subjected to a 3.5% (NaCl) solution. The best microhardness and adhesion strength values can be achieved by increasing the h-BN concentration (1.5 to 2.5) wt.% in the plating baths. For instance, electroplating with h-BN at a concentration of 15.75 g/l yields a microhardness of 606.7 HV and an adhesion strength of 14.48 MPa. Similarly, hot dip galvanizing with h-BN at a concentration of 2.0% results in a microhardness of 542.1 HV and an adhesion strength of 10.28 MPa. Lastly, when using h-BN at a concentration of 2.5% in ZRC, the microhardness and adhesion strength values obtained are 557.8 HV and 8.5 MPa, respectively. The incorporation of h-BN nanoparticles resulted in a significant improvement and augmentation of the thickness of the coating exhibited the least amount of porosity and the most uniform dispersion when compared to other Zinc composite coatings, namely Zinc electroplating (with a thickness of 97 μm of h-BN at a concentration of 21 g/l), Zinc hot dip (with a thickness of 144 μm of h-BN at a concentration of 2.5%), and ZRC (with a thickness of 123 μm of h-BN at a concentration of 2.5%). Moreover, the utilization of Tafel extrapolation curves and corrosion analysis has demonstrated that Zinc- based coating techniques, when reinforced with the incorporation of h-BN, exhibit significantly improved corrosion current densities (icorr) and corrosion rates (CR). Zinc electroplating technique with h-BN at a concentration of 15.75 g/l yields current density and corrosion rate values of 0.72 $\mu A/cm^2$ and 0.00659 mpy, respectively. Similarly, Zinc hot dip with a 2.0% h-BN concentration results in current density and corrosion rate values of 3.5 $\mu A/cm^2$ and 0.032 mpy, while ZRC with a 2.5% h-BN concentration exhibits values of 5.2 $\mu A/cm^2$ and 0.04758 mpy. OM, SEM, XRD, and EDS mapping analysis were used to characterize the Zinc composite coating's grain structure, grain size, nanoparticle distribution, and chemical composition. The coating matrix contained Zinc and h-BN nanoparticles without impurities. h- BN in the composite coating does not affect grain size. As nucleation sites, h-BN nanoparticles can reduce porosity and refine grains after integration.
Subjects: Materials Chemistry; Corrosion-Materials Science; Surface Engineering-Materials Science.

1. Introduction

Weathering steel has been widely used in many applications including the construction of bridges, railways, ports, buildings, heat exchangers, and pipelines because of its exceptional resistance to corrosion. In addition, galvanizing the Weathering steel with Zinc based coating enhances corrosion resistance when subjected to a corrosive environment. Electroplating, hot dip, and Zinc rich coat (ZRC) are the three commonly used techniques that are utilized the most frequently in the production of Zinc-based galvanized steel sheets. The coating's performance is influenced by its microstructure and surface characteristics [1]. Grey cast iron with a Zinc electroplating coating was subjected

* Corresponding author.
E-mail address: engpg.dhurgham.ali@uobasrah.edu.iq (D.A. Mohsin).

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