Research Article

Ahlam Hamid Jasim, Nabaa S. Radhi, Noor Emad Kareem, Zainab S. Al-Khafaji* and Mayadah Falah

Identification and investigation of corrosion behavior of electroless composite coating on steel substrate

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Abstract: Because it is essential to avoid toxicity and corrosion in order to enhance the steel components and their aesthetic magnitude used in our everyday life, there has been an increased interest in the electroless field, particularly with regard to the application of nickel-phosphor on steel substrates. In this work, electroless process by nickel low phosphor solution and added titania particles (10–30 μm) to amount of coating solution (0, 5, and 10 g/L) with different coating times (30 and 60 min). Then, many tests were conducted, involving coating thickness, surfaces roughness, hardness, energy-dispersive X-ray spectroscopy, scanning electron microscopy, and linear polarization tests in salt solution that were carried out for substrate and coating layers. Hardness indicates that the mechanical characteristics of the applied coatings with incorporated (TiO_2) reinforcement were far more superior to its own matrix as well as noncomposite nickel coating. The polarization curves conducted by potentiodynamic technique for different coating layers with 3.5% NaCl a medium and find all data by computerize, which shows that the addition of TiO_2 extract improved the corrosion rate (67.58%) than uncoating specimen.

Keywords: corrosion, composite coating, electroless, steel substrate

1 Introduction

The deterioration of metallic due to corrosion results in significant financial losses. There are a significant corrosion impacts on the metal structures of buildings and bridges, as well as the chemical plants and metallurgical equipment, sea ships, river and pipelines underground, and a great deal of other structures [1,2]. Some nations have incurred the expense of conducting corrosion investigations. For instance, corrosion causes losses in America that amount to $100 billion every year, which is equivalent to around about 5% of the country's total gross domestic product. Costs associated with directly attributable losses due to corrosion include those incurred in the process of substituting specific components, units, plants, or complete lines, in addition to a wide variety of preventative and protective measures (including the use of coatings for corrosion protection). Once rusted, equipment results in faulty items that must be thrown out, and indirect losses are incurred. Corrosion causes a loss of around 30% of cast iron and all steel [3]. A portion of this metal may be processed as scrap, although there is a loss of around 10% of it [4,5].

The deposition of a layer to the metallic surface seems to be the procedure that is shown to be the most successful in preventing the metal from corroding. The coating serves as a protecting barrier between the metallic surface and the surrounding environment. Furthermore, it has the ability to serve as a sacrificial anode [6–10]. The surface might be shielded from environmental assault by the use of a metallic, inorganic, or organic coating, to increase the life of the surface or the life of the complete or component equipment [11]. The existence of metallic coatings, which

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*** Corresponding author: Zainab S. Al-Khafaji,** Department of Civil Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia; Scientific Research Center, Al-Ayen University, Thi-Qar, Iraq; Department of Design, Al-Turath University College, Baghdad, 10013, Iraq,
e-mail: zainabcivil90@gmail.com, p123005@siswa.ukm.edu.my, Zeinab.radi@alayen.edu.iq
Ahlam Hamid Jasim: College of Engineering, Al-Qasim Green University, Babylon, Iraq, e-mail: ahlam.hamid@wrec.uoqasim.edu.iq
Nabaa S. Radhi: College of Materials Engineering, Babylon University, Babylon, Iraq; College of Biotechnology, Al-Qasim Green University, Babylon, Iraq, e-mail: mat.nabaa.sattar@uobabylon.edu.iq
Noor Emad Kareem: Department of Civil Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia,
e-mail: noor.emad@biotech.uoqasim.edu.iq
Mayadah Falah: Building and Construction Engineering Technology Department, AL-Mustaqbal University, Babylon, Iraq,
e-mail: Mayadahwaheed@mustaqbal-college.edu.iq
ORCID: Zainab S. Al-Khafaji 0000-0002-5450-7312

could either act as sacrificial coatings or act as barrier coatings, boosted the resistance to the corrosion of metals. Electroless plating, chemical and physical vapor depositions, hot-dip galvanizing, high-velocity spray coatings, and electroplating are some of the methods that may be used to create these types of coatings. The primary use for these metal coatings is to protect alloy low steels from the damaging effects of corrosion [12–15].

The coatings provide a deposit that is resistant to corrosion, while the pure material produces the load-bearing capacity. The metal coatings, such as cadmium, copper, nickel, and chromium, are often produced by wet chemical procedures; nevertheless, this method is fraught with difficulties regarding environmental impact [16–18]. Many wet approaches have evolved alongside the deposition procedures and will likely play an important part in the further development of that coating [13–15,19]. Gold, silver, and copper are also occasionally used for specialized fastening applications, in addition to their uses in electrical devices [20]. Composite deposition seems to be a coating protection method that involves depositing homogeneously inactive particles of a variety of material into the metal matrix; this two-phase coating enhances resistance to corrosion and mechanical characteristics. Composite deposition is also known as "composite plating." The improvement of these qualities is dependent on the presence of metal particles in addition to the metal matrix. The electrodeposition of composite coatings comprises pure metals or alloy matrix that contains hard particles such as SiO_2, WC, SiC, TiO_2, and Al_2O_3 as second phases [21,22].

Electroless and electro- and composite coatings provide a method that is both cost-effective and efficient for engineering the surface in order to acquire desired properties, including resistance to hardness, wear, abrasion, and corrosion [23–26]. These coatings may be produced by codepositing a variety of second-phase particles into an electroless or electrodeposited alloy matrix or metal. Codepositing is possible with almost any kind of particulate that could be kept in suspension without interacting with the plating bath. Hard particles (such as oxides of Zr, Th, Ti, Si, Ce, and Al; carbides of Cr, W, Ti, and B; nitrides of Si and B; and borides of Ti and Zr; synthetic and natural diamond) and soft particles (such as graphite, CaF_2, MoS_2, polytetrafluoroethylene, and WS2) improved materials such as inorganic fullerene and carbon nanotube. In today's world, technical interests are being driven by the capacity to manufacture novel composite materials that have desirable features via the use of micro- and nanoparticles. This enhancement is mostly based on the proportion and size of particles that make up the codeposition, as well as the dispersion of these particles throughout the metallic matrix [21,27]. Depending on the assessments of the works that have been published, composite coatings that have been created by electrochemical co-deposition may be divided into three distinct categories [28].

Ni–B–TiO_2 composite coatings have been developed by Antar et al. [29], and they were made by including TiO_2 sol in the bath solution during the preparation process. Several different tests, such as scanning electron microscopy (SEM), X-ray diffraction, microhardness testing, progressive load scratch testing, reciprocating sliding testing, and multi-pass scratch testing, have been conducted in order to achieve the goal of conducting a study that was comprehensive. According to the findings, the microstructure of the Ni–B matrix was significantly altered as a consequence of the presence of crystalline or amorphous TiO_2 structures. Because of its compact structure, the Ni–B deposit exhibited greater scratch reaction and better wear resistance as a result of using this material. Ashassi-Sorkhabi and Rafizadeh [30] explored the effects of thermal treatment and coating duration on the corrosion behaviors of electroless Ni–P covered on mild steel specimen and exposed to 3.50% solution of NaCl. Their findings showed that heat treatment and coating time had a substantial effect on the corrosion behaviors. They have demonstrated that an increase in time that the electroless Ni–P coating is applied to specimens of mild steel results in a reduction in the corrosion rate for those samples.

The Ck-45 was produced by Ashtiani et al. [31]. A nickel–phosphorus alloy was already electroless-coated onto steel using a bath that comprises sodium hypophosphite in addition to a range of complexing agents. The coating was produced via electroless coating (including lactic acid, sodium citrate, and sodium acetate). Researchers have investigated the effects that a wide range of complexing agents have on the composition of phosphorus, as well as the hardness of deposits, their morphology, and structures. Latha et al. [32] have conducted research on the electroless nickel plating process using an optimum bath by varying the deposition period from 21,800 swhile maintaining a temperature of 80°C and a pH of 4. In order to investigate the reflectance surface of deposits, elemental composition, structure, and morphology, an X-ray diffractometer, spectroscopic investigations, energy-dispersive X-ray analyses, an atomic force microscope (AFM), and a SEM were used.

Utilizing Box-Behnken Design (BBD) experiments, Sarkar et al. [33] concentrate on the parametric optimizing of electroless Ni-Co-P coating utilizing surface roughness as a response. To forecast the fluctuation in surface roughness, two bath parameters—the concentration of sodium hypophosphite and cobalt sulphate—were adjusted in conjunction with the bath temperature. In order to ascertain the interactions of the significant components that predominate the coating's surface roughness, the analysis of variance (ANOVA) approach was used. Under ideal