coatings

Editorial

Special Issue: Surface Modification of Magnesium, Aluminum Alloys, and Steel

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The subject of coatings is mainly analyzed in different fields. There is currently an interesting study on this topic. For example, ref. [1] aims to clarify important aspects regarding the use of marine coatings and preservatives for corrosion protection purposes. The purpose of this review is to describe in detail the state of the art in anti-corrosion coating systems. International and national legislation aimed at reducing VOC emissions has brought about major changes in the anti-corrosion coatings industry. This review, which is mainly related to European experience and practice, describes the various environments to which corrosion-resistant coating systems may be exposed during service. Test methods and standard examples for anti-rust and anti-corrosion coatings are also given. It introduces the types of anticorrosive paints and describes the types of binders and pigments commonly used in anticorrosive paints. In addition, they differ in barrier layers, victim defense mechanisms, and inhibition. In recent years, a few alternative paints to organic solvent-based paints have entered the commercial market. This overview also introduces the technology and discusses its strengths and limitations. Finally, the mechanisms leading to the decomposition and degradation of organic coating systems are described and types of adhesion loss are discussed.

Magnesium and its alloys have excellent physical and mechanical properties for a variety of applications [2,3], which solves the strength-to-weight ratio problem of this material, making it suitable for automotive and aerospace applications. It is the ideal metal for your application. Reduction is an important problem. Unfortunately, magnesium and its alloys are very corrosive, especially in salt spray conditions. This limits their use to the automotive and aerospace industries, which are less likely to be exposed to adverse operating conditions. The easiest way to prevent corrosion is to coat the board with magnesium to prevent exposure to the environment. This review describes the state of the art in surface modification and coating techniques used to improve and regenerate corrosion on magnesium-based substrates. Topics include electrochemical coatings, conversion coatings, anodizing, vapor deposition processes, laser coatings/surface coatings, and organic coatings.

Clinical applications of bioabsorbable magnesium (Mg) and its alloys are limited due to their poor corrosion resistance. In addition to elemental alloys, surface modification and functionalization are important ways to improve the corrosion resistance of magnesium alloys. Refs. [4,5] reviewed the development and progress of biodegradable surface coatings of Mg alloys over the past decade and aimed to build a knowledge base on the surface modification of biodegradable Mg alloys. Transformation, deposition, mechanical and functional coatings and their production methods are presented. Emphasis is placed on chemically modifying compounds to overcome the advantages of adhesion, corrosion resistance, and the biocompatibility of individual coatings on biomedical materials. Issues related to the integration of structural and functional factors in composite coatings were discussed.

There are also protection problems in the medical field. In this context, self-healing clothing inspired by biological systems that can repair physical damage or restore functional activity are mentioned. Refs. [6,7] support a comprehensive and state-of-the-art investigation of the advantages and limitations of autonomous and non-autonomous self-healing mechanisms common to organic protective coatings for anti-corrosion applications. By adding polymerizable hardeners or corrosion inhibitors to the coating matrix, self-healing mechanisms are activated. In non-autonomous mechanisms, therapeutic effects are produced by external heat or light stimuli that induce chemical reactions or physical transitions necessary for bond formation or molecular chain movement.

The thickness has a great influence on the performance of the coating. Therefore, the technique used to find the thickness is of great importance for coating research and technology. Ref. [8] described the most suitable method for finding the thickness of metal coatings. Therefore, technologies are divided into two categories: destructive and non-destructive. The authors list the features and precisions of each of these methods, emphasizing their advantages and practical aspects such as the complexity of the procedure and the time to result. Although the analysis focuses on metallic coatings, the method can also be applied to the films of other materials.

Currently, in the field of coatings, this shows that the development of edible films and coatings has increased rapidly in recent years and should have a significant impact on food quality and processing technology in the coming years, as well as developing an increased knowledge about film and clothing. The aim of edible coating technology is to reduce synthetic packaging by using environmentally friendly biodegradable packaging or protective covers on food surfaces. Bio-based polymers have been used to produce edible films and coatings. Food raw materials and new processing techniques are topics of interest because of their potential to be used as innovative food packaging systems. Ref. [9] summarizes various data on new film-forming materials, such as plant residues, flours, and pulps, demonstrating their effectiveness and suitability for the preservation of various foods.

Corrosion is an expensive and safety problem in many fields, but the use of nanocomposite coatings as a suitable method of corrosion protection is the goal of today's researchers. Recent studies reported by [10,11] have investigated the potential use of nanocomposite coatings for corrosion control. In an overview of the recent revival of corrosion protection, we discuss the factors that affect the performance of nanocomposite coatings, including the types, sizes, concentrations, blends, and impurities of nanomaterials. This research focuses on alkyd resins, epoxy resins, and polyurethane compounds. In addition, new materials in the design of nanocomposite coatings are reviewed and future approaches are discussed.

Nanocomposite coatings based on the addition of inorganic nanofillers to polymer matrices are a new class of corrosion protection with better corrosion resistance and mechanical performance compared to conventional composite coatings. Inorganic nanomaterials, such as metal nano powders, metal oxides, nano glass flakes, nitrides, carbides, and nano calcium carbonates, have an attractive potential to improve the barrier properties of polymer coatings. Refs. [12,13] reviewed the influence of nanomaterials on the anti-corrosion performance of polymer coatings and reviewed recent studies on the corrosion resistance of these nanocomposite coatings. This review clearly shows that the properties of nanocomposite coatings depend on the nanoparticle type, morphology, size, specific surface area, nano filling fraction, chemical structure, functional groups, and nanoparticle–nanoparticle interactions. Nanomaterials can be well dispersed in polymer matrices with high corrosion resistance and there are various methods based on synthetic methods and physicochemical/mechanical surface treatments to achieve this goal. Furthermore, it is important to develop nanocomposite coatings using environmentally friendly approaches without modifying the intrinsic properties of the nanofillers and without using toxic chemicals to modify the nanofillers.

Over the past 14 years, HEA films and coatings in the field of high entropy alloy (HEA) materials have shown interesting and unique properties compared to conventional films and coatings. This article reviews the latest research and developments in HEA films and coatings. First, the basic concepts of HEA films and coatings are presented. Since then, manufacturing techniques, microstructures, and interesting properties have been developed [14,15]. In addition, we discuss possible reasons and the design criteria for achieving a superior quality. Finally, future research on HEA films and coatings is recommended. This article describes the fabrication techniques, microstructures, and properties of HEA films and coatings. The design criteria and suggested research guidelines were presented in the reviewed study and are available in [9].

Corrosion of metal parts is a major problem in the aerospace industry, causing safety hazards and significant economic losses. Hexavalent chromium-based conversion coatings provide corrosion protection at a relatively low cost. However, environmental and health concerns have increased interest in the development of alternative technologies. Not only should it be economical and environmentally friendly, but it should also have corrosion resistance and adhesion comparable to Cr6+-based CC. Meeting these criteria is also a challenge and only a few systems have been implemented industrially so far. Research [16,17] reviews the latest research and patent literature on chromium-free CC in aluminum alloys and evaluates its potential for aerospace applications. Bath compositions and properties of trivalent chromium process coatings, rare earth conversion coatings, O metal anion compounds, Zr/Ti-based conversion coatings, gel–gel coatings, and smart stimulant emission blocking coatings. As the aerospace industry faces the need to phase out chromium in the near term, the pros and cons of alternative technologies for practical applications are being debated.

Aluminum and its alloys are widely used as lightweight materials in many industries, but they have poor corrosion and wear resistance and a low strength. Fortunately, this problem can be solved with surface modification methods, including plasma electrolytic oxidation (PEO) technology. This technique can produce uniform, thick, strong, abrasion- and corrosion-resistant, and highly adhesive coatings. As an important factor, the use of different solutions in the PEO procedure can result in different coating structures, compositions, and properties. One of the advantages of the PEO process is the introduction of various impurities into the solution to create coatings with suitable properties. Carbon nanotubes can be a good choice to validate the properties of PEO coatings due to the important properties of carbon caltrops such as graphite, diamond, and graphene. These additives reduce the penetration and rate of corrosive ions in the coating, combine to absorb these components in the PEO coating, reduce the number and size of cracks or cells, and increase the thickness and density of the coating and increase it. When it comes to corrosion protection, from a wear perspective, this compound provides increased wear resistance due to the density and stiffness of the coating or, in other cases, the self-lubricating properties of the compound. Therefore, studies [18,19] analyzed the corrosion effects of PEO coatings applied to aluminum and its alloys and the effect of carbon allotropes on corrosion.

Ref. [20] used a bis-silane prepolymer instead of epoxy resin to improve the corrosion resistance of epoxy coatings on aluminum alloy substrates. A bis-silane prepolymer was prepared using tetraethoxysilane (TEOS) and γ-glycidoxypropyltrimethoxysilane (GPTMS). The corrosion behavior of the silane-epoxy coating was investigated. Compared to silane monomer modified epoxy coatings, bis-silane-modified epoxy coatings have a lower coverage (Cc), higher charge transfer resistance (Rdl), and lower double layer capacity (Cdl). Bis-silane-modified epoxy coatings have been shown to improve the waterproof permeability and corrosion protection of substrates. Additionally, due to the leaching of silane moieties during the dipping process and the cross-linking reaction between different silanes, the bis-silane-modified epoxy coatings exhibited a higher "self-healing" ability.

The electrolytic system has a major influence on plasma electrolytic oxidation (PEO). Refs. [21,22] used FESEM to study the surface, aluminum/coating (A/C) interface, fracture surface microstructure, and the elemental distribution of PEO coatings prepared with silicate, phosphate, and electrolyte. It is also discussed the growth mechanism of PEO coatings in different electrolytes. The results show that the coating growth in the silicate system is dominated by silicate and there are loose joints on the coating surface. Elemental Si covers almost the entire garment and is abundant at the joints and edges of the cavities. In the phosphate system, the growth of the coating is mainly due to the oxidation of aluminum. The "mountain" is like a rock in the air conditioner interface. The main component of this film was α-Al_2O_3, and a small amount of P was diffused at the A/C interface. The mixed electrolyte deposition process is mainly matrix oxidation and accompanying electrolyte deposition. Meanwhile, the growth pattern of PEO coatings with different electrolytes appeared.

Ref. [23] presents the results of the study that aimed to evaluate the effect of the duty cycle (D) during plasma electrolytic oxidation (PEO) on the morphology, composition and protective properties of coatings produced in aluminum alloy 5754 in a mixed electrolyte. Electrolytes requiring evaluation are produced. Increasing the duty cycle of the microsecond current pulse has been shown to decrease the porosity and increase the thickness of PEO layers containing γ-Al_2O_3, β-Al_2O_3, $AlPO_4$, and Al_2Mo_3C. This improves the barrier properties and microhardness of the coating. Young's modulus increases with increasing power due to changes in the morphological and chemical structure of the coating. PEO coatings produced with longer duty cycles and longer oxidation times are more wear resistant than those formed with shorter oxidation times and lower D values. The data obtained allows us to evaluate hypotheses about the mechanism of phase formation.

As a brief introduction to the field of coatings, this Special Issue aims to promote the dissemination of qualitative research on the relationships between mechanical properties and processing methods, microstructural properties, and chemical composition. The subject areas are broad and aim to include interesting and innovative research that contributes to the development of this interdisciplinary field of study. It also aims to promote scientific innovation in materials science and visualize the research potential of materials science and engineering.

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