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Editorial

Special Issue on "Advances in Organic Corrosion Inhibitors and Protective Coatings"

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Featured Application: This Special Issue collects new findings and recent advances in the development, synthesis, and structure–activity relationships of organic corrosion inhibitors and protective coatings.

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1. Introduction

Metallic components consisting of magnesium, aluminum, steel, and their alloys are widely used in a plethora of applications because of their exceptional mechanical properties and their overall durability. However, they are often damaged by mechanical or chemical processes. Mechanical damage that is caused by the impact of solid particles is called erosion, while electrochemical damage that results from chemical degradation is termed corrosion. The corrosion phenomena, to which every metallic substrate is subjected, eventually result in the degradation of the metal and the deterioration of its properties.

The interaction of a metal with its environment that results in its chemical alteration is called metallic corrosion. According to the literature, corrosion is classified into two types; uniform and localized corrosion. The intervention of either in the alloy environment or in the alloy structure can influence the corrosion protection of metallic materials. Furthermore, the interference in the metal alloy environment can be conducted with the utilization of cathodic or anodic protection via the corresponding inhibitors. Therefore, the most common categorization is among cathodic, anodic and mixed-type inhibitors, taking into account which half-reaction they suppress during corrosion phenomena. The majority of the organic inhibitors are of mixed-type and perform through chemisorption.

Corrosion control of metallic structures is an important task in technical, economic, environmental, and safety terms. Several types of corrosion inhibitors are being employed to prevent metallic dissolution in corrosive media, for which the use of organic inhibitors is one of the most frequent and economic methods. Heteroatoms (O, S, N, and P) and π-electrons in the conjugated form act as excellent corrosion inhibitors for metals and alloys in aggressive solutions [1]. These inhibitors can be incorporated into corrosion-protective coatings. Coatings considered for corrosion inhibition must offer an effective physical barrier, impeding the access of violent materials to the metal surface.

In order to update the field of corrosion protection of metal and metal alloys with the use of organic inhibitors, a Special Issue entitled "Advances in Organic Corrosion Inhibitors and Protective Coatings" has been introduced. This editorial manuscript gathers and reviews the collection of ten contributions (nine articles and one review), with authors from Europe, Asia and Africa accepted for publication in the aforementioned Special Issue of Applied Sciences.

2. Corrosion Inhibitors

Steel has gained an increasing utilization and is widely used for machinery parts, building construction, and pipelines, because of its low price as well as its machinability and weldability. Three articles were published in this Special Issue related to corrosion protection of steel in the presence of inhibitors. The corrosion resistance of mild steel under the conditions used for industrial applications was investigated by Kartsonakis et al. [2]. Their study investigated the application of organic 2-mecraptobenzothiazole (MBT) and inorganic Na_2HPO_4 as corrosion inhibitors for the protection of API 5L X42 pipeline steel. The electrochemical characterizations proved that both compounds can be considered as corrosion inhibitors of steel and the corrosion protection mechanisms can be assigned to the protective layers created onto the metal surface through chemisorption of the inhibitors, which prevent chloride's penetration. The synergistic effect of the MBT and Na_2HPO_4, in a molar ratio of 1:1, revealed the effective performance of the additives with corrosion inhibition efficiency above 90%.

Lahrour et al. [3] investigated the use of glycerin-grafted starch as a bio-copolymer working as a corrosion inhibitor for the protection of C-Mn steel, in the presence of HCl, by electrochemical techniques and the weight loss method. The obtained results revealed that inhibition efficiency enhances with increasing bio-copolymer concentration, reaching a maximum of 94%. Moreover, it was concluded that the corrosion inhibition mechanism might be not only a simple physisorption process on the steel surface, but can also be explained in terms of chemisorption of polymer on the steel surface. The corrosion behavior of steel reinforcement incorporated in mortar specimens, in which both the cement and aggregate are partially substituted by ladle furnace slag (LFS) in respect of the presence of chloride ions, was investigated in the work of the Prieto et al. [4]. Electrochemical techniques were used to estimate the corrosion rate as well as the symptoms created in steel rebars in the presence of LFS. Considering the obtained results, it was concluded that in mortars with the presence of mixed-in chlorides, the embodiment of LFS in the mortar at the time of kneading does not negatively influence the corrosive process of the steel rebar.

In recent years, studies on copper alloy corrosion have gained much attention in the industrial sector due to the fact that copper and its alloys create several industrially important materials. Many important properties ranged from good thermal properties, formability, electrical conductivities and visual appearance to good corrosion resistance influenced by the alloying elements of copper. Two articles based on copper alloy corrosion protection were published in this Special Issue. In the work of Kozaderov et al. [5], the corrosion inhibition efficiency of 3-mercaptoalkyl derivatives of 5-amino-1H-1,2,4-triazole for the a-brass (copper > 65 wt.% and zinc < 35 wt.%) in a chloride media was investigated using electrochemical techniques. Taking into account the obtained result, it was estimated that the degree of protection achieved for all inhibitors can reach a maximum of over 99%. Moreover, it was proven that the protective effect enhances with the length of the alkyl chain. The corrosion protective mechanism is based on the formation of a protective film on the a-brass surface that contains oxides as well as complex compounds of copper and zinc with the inhibitor molecules.

In the work of Shinato et al. [6], the protection role of cysteine for the copper-based alloys Cu-5Zn-5Al-1Sn, containing zinc (5 wt.%), aluminum (5 wt.%) and tin (1 wt.%) corrosion in sodium chloride solutions, was studied. The electrochemical results proved that the inhibition efficiency improved with increasing cysteine concentration. Furthermore, the results of the surface analysis techniques indicated that the corrosion inhibition was based on the adsorption of the inhibitor molecules onto the copper alloy surface.

Aluminum alloy is one of the most widely used materials in the subsea industry due to its excellent thermal conductivity, low cost, acceptability for short-term development, good strength, and low density. One article related to corrosion protection of aluminum alloy 7075 was published in this Special Issue. The study of Seo et al. [7] examined the corrosion resistance of oil impregnated anodic aluminum oxide surfaces of aluminum 7075 for subsea application. Several experiments were conducted based on contact angle measurements together with salt spray and pressure tests. The obtained results revealed that the corrosion resistance of aluminum 7075 could be improved by oil impregnation on the aluminum alloy surface, and therefore can be used in the subsea industry.

3. Corrosion Protective Coatings

In general, three different types of coatings exist for corrosion protection of metal alloys. Barrier coatings prevent the aggressive elements from coming together with the substrate to onset the corrosion process. Inhibitive coatings actively block the electrochemical reaction from happening by interfering with the electrolytes needed to start the corrosion process. Sacrificial coatings are a type of metal coatings that become more oxidated than the metal surface they protect. Three articles and one review based on corrosion protective coatings were published in this Special Issue. In the work of Shi et al. [8], smooth coatings of TiNb and TiNbN were deposited on 316L stainless steel by magnetron sputtering in order both to improve the corrosion resistance and the electronic conductivity of bipolar plates for proton exchange membrane fuel cells.

In the study by D'Elia et al. [9], poly(phenylene methylene)-based coatings were developed for corrosion protection of aluminum alloy AA2024. These copolymer-based coatings contained n-octyloxy side chains and their anti-corrosion behavior was estimated via several electrochemical methods. The obtained results revealed that these coatings exhibited good corrosion protection of the metal surface towards a sodium chloride solution. Thin multifunctional coatings of cerium oxide nanoparticles with anti-reflective properties were developed onto glass and silicon substrates by Romasanta et al. [10]. These coatings could be used as an intermediate layer between air and substrates for providing anti-reflection features. Finally, in the review paper of Fu et al. [11], the advances and challenges of corrosion and topology detection of grounding grid are discussed. This paper presents the research status of grounding corrosion and topological detection in detail and introduces the basic principles, research difficulties and existing problems of the methods such as the electromagnetic field method, electric network method, ultrasonic detection method, electrochemical method and electromagnetic imaging method.

4. Future Strategies

Although the Special Issue has been closed, more in-depth research in the field of corrosion protection technologies with the use of organic inhibitors together with coatings development is expected. It can be anticipated that more friendly applications will be demanded in large numbers in the future for the protection of metal alloys against corrosion.

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