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Editorial

Special Issue: Environmental Corrosion of Metals and Its Prevention: An Overview and Introduction to the Special Issue

Boxin Wei [1,2] and Jin Xu [1,2,*]

[1] Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China; bxwei17s@imr.ac.cn
[2] School of Materials Science and Engineering, University of Science and Technology of China, Shenyang 110016, China
* Correspondence: xujin@imr.ac.cn

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Corrosion is a natural process of deterioration and an extremely costly problem. According to a US survey, the corrosion cost has been estimated to be USD 23.4 billion, which is 2.7% of the GDP in the United States. Globally, the cost of corrosion is estimated to be USD 2.5 trillion, which is ~3.4% of the global GDP (2013). However, in China, that amounts to more than USD 390 billion a year, equivalent to 4.2% of GDP [1]. In addition to the global economy, health, safety, and environment (HSE) are often at risk in certain environments where corrosion is rampant.

Corrosion is an all-too-common process of degradation that results from chemical or electrochemical reactions between the material and its environment. Environmentally induced corrosion of material is a global issue that affects many industries, such as oil/gas production, transportation, infrastructure, biofuels refining, and geothermal energy production [2]. The hazard of the corrosion of material usually originates in its service environments, such as corrosive ions, stress, microbes, etc. For example, the oil and gas industries create hazardous environments in terms of corrosion, as the relatively complex composition of oilfield brines and oils, with a plethora of chemicals that can interact with materials, results in enhanced corrosion. Metallic materials that are exposed to H_2S, CO_2, and organic acid are susceptible to corrosion damage. Localized pitting corrosion always occurs in the existence of some aggressive anions, such as a chloride ion (Cl^-), which is identified as one of the most destructive forms of corrosion [3].

Stress corrosion cracking (SCC) is a particular process of environmentally induced cracking, which is a dangerous and complicated type of corrosion failure. It should be noted that, under tensile stress loading that is otherwise considered a safe condition, SCC can cause slowly developing subcritical cracks in a specific corrosive environment. Once the critical crack size is reached, the combination of cracking and the tensile stress load causes a sudden, catastrophic, and rapid fracture of materials. This type of corrosion can exert a considerable economic and environmental impact on virtually all facets of the world's infrastructure, from oil and gas pipelines to aircraft structures, chemical processing, and water and wastewater systems.

More recently, there have been increasing concerns about the role of environmental microbes on corrosion, which is known as microbiologically influenced corrosion (MIC) [4–6]. MIC has been considered a significant problem in the oil and gas industries [7,8]. Pitting attacks by MIC tend to result in reservoir souring and material failures that lead to great disasters in these industries [9,10]. Among the different types of bacteria, sulfate-reducing bacteria (SRB) have critical roles in severe MIC. In terms of mechanism, MIC is relatively subtle, and no MIC system currently exists with a mechanism that is fully understood [11–13]. At best, there are systems for which there are good models to describe certain aspects of the overall process. Furthermore, there is a synergistic effect of MIC and SCC to accelerate the corrosion process [14]. Thus, a mechanistic model to allow an understanding of environmental influences may concentrate on different aspects that differ from those important in our understanding of the mechanism of SCC propagation. This also brings new challenges to our understanding of corrosion mechanisms in changing natural environments.

Thus far, numerous actions have been taken to mitigate the magnitude of corrosion reaching unsustainable costs, such as corrosion inhibitors [15], biocides [16], cathodic protection (CP) [17], and protective coatings [18]. In fact, 25% to 30% of annual corrosion costs would be saved if best practices for corrosion protection were employed. The application of inhibitors to extensively corrosive material that is in contact with an aggressive environment is a successful practice. Various kinds of organic and inorganic compounds have been developed and applied to many systems, such as oil and gas production units, cooling systems, refinery units, boilers, etc. [19,20], all of which have shown significant inhibition potential. For instance, some coatings modified with antibacterial activity have been reported to control MIC via biocide leaching [21,22], adhesion resistance [23], or killing the bacteria [24]. In addition, surface cleaning and preconditioning surface processing to improve corrosion resistance is a promising strategy to prevent corrosion, particularly in hostile environments. To successfully address the specific problems related to corrosion, there is an urgent need for an in-depth understanding and deep knowledge of corrosion mechanisms, to carefully design each method of protection.

Although several publications have already been reported in the field of environmental corrosion and its prevention, research on these topics proves to be an increasing concern, in terms of both the number of publications and their impact, as indicated by the number of studies published in different journals. We believe that the articles in this Special Issue provide compelling contributions to advancing the present corrosion practice.

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