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Editorial

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New frontiers in marine corrosion research

Marine environments present some of the most challenging conditions for structural materials. Continuous innovation and fundamental understanding of corrosion mechanisms are essential in order to mitigate degradation. The collection on "Marine Corrosion" compiles 19 articles that explore a broad spectrum of materials and techniques aimed at addressing corrosion in marine environments. The research within not only advances our understanding of corrosion processes, but also offers practical solutions for industry.

Corrosion in marine environments is particularly aggressive due to the combined influence of chemical, mechanical and biological factors - which together accelerate material degradation. It is a crucial concern for industries reliant on durable marine infrastructure, including offshore wind farms, pipelines, and maritime vessels. The topics addressed in this issue highlight the importance of material selection, surface treatments, and alloying elements in enhancing the longevity and performance of structures exposed to such conditions. The application of advanced techniques, such as sol-gel treatments, plasma ion nitriding, and additive manufacturing (AM), allows for the development of future corrosion-resistant materials.

Surface treatments and coatings

Several papers within this issue focus on novel coatings and surface treatments that improve the corrosion resistance of materials in marine environments. For instance, Linder et al.[1] investigate the corrosion resistance of additively manufactured (AM) aluminium alloys, which exhibit significant potential for marine applications. Another study by Li et al.[2] evaluates Cr/GLC coatings sealed with Al_2O_3, demonstrating their capacity to withstand high hydrostatic pressures. In addition, a mini-review on metallic coatings for offshore wind structures by Syrek-Gerstenkorn and Paul[3] highlights the growing demand for durable coatings as renewable energy infrastructure expands offshore to meet net-zero targets. The repair of carbon steel oxide scales using Ce^{3+} and Ni^{2+}-doped sol-gel coatings, as discussed in the article by Zeng et al.[4], further exemplifies how integrating chemical and physical processes can significantly enhance surface protection against marine corrosion.

New alloys and corrosion mechanisms

A key theme throughout this special issue is the role of alloying in enhancing corrosion resistance. Research examining the corrosion behaviour of high-strength, anti-seismic rebar, influenced by Nb and V additions, offers critical insights for the construction of durable structures in earthquake-prone coastal areas[5]. Similarly, the study on Mg–9Gd–3Y–2Zn–0.5Zr alloy by Chen et al.[6] under simulated coastal storage conditions provides crucial findings for the development of lightweight materials, potentially reducing the maintenance costs associated with maritime structures. The influence of alloying elements such as Mo, Sn, Al, and Mn is also thoroughly examined. For instance, the paper by Sun et al.[7] assesses the combined effects of Mo and Sn on the corrosion behaviour of low-alloy steel in tropical marine atmospheres, while Tang et al.[8] demonstrate how the incorporation of Al and Mn optimizes rust layer formation on lightweight weathering steel, resulting in better understanding of corrosion resistance. The influence of Cr(III) on the formation and transformation of corrosion products of steel in marine environments is covered in detail in the paper by Serjaouan et al.[9]. Nitrogen is known to play a key role in the corrosion resistance of austenitic stainless steel and was envisioned in the paper by Gao et al.[10] as an alternative element to develop new alloys with low Ni contents. Their work showed that high-nitrogen austenitic stainless steels (HNSS) have larger proportion of stable oxides in the passive films that facilitates the passivation/re-passivation process and contributes to the high corrosion resistance.

A fundamental aspect of corrosion research is understanding the underlying mechanisms that drive material degradation. Several studies in this issue focus on the electrochemical behaviour of materials in marine environments, including kinetic model development for steel corrosion[11]. The effects of plasma ion nitriding and electropolishing on the electrochemical resistance of UNS N08367 alloy (6% molybdenum super-austenitic stainless steel) is explored by Hwang and Kim[12], while Laleh et al.[13] introduces an innovative electrode array probe capable of simultaneously monitoring multiple localised corrosion processes in marine structures.

Biocorrosion and biofouling

Additionally, research on microbiologically influenced corrosion (MIC) enhances our understanding of how microorganisms, such as *Bacillus cereus*, contribute to stress corrosion of Cu-bearing steel[14]. The study of Cu-bearing steel presents promising strategies to improve resistance to MIC, a growing concern in long-term maritime operations. Another consequence of the interactions between materials surfaces and the biologically active natural seawater is biofouling. Like corrosion, it can threaten the functioning and integrity of marine structures. To hinder biofilm formation, Wu et al.[15] tested successfully the effect of a natural antibacterial peptide and investigated the mechanisms of its action using a combination of complementary techniques.

Materials processing

Welding and additive manufacturing (AM) are critical to the construction and maintenance of structures, and several articles in this issue address the specific corrosion challenges associated with these processes. The corrosion performance of wire arc additively manufactured nickel–aluminium bronzes (NAB) is examined by Shahriari et al.[16], providing valuable data for industries utilising AM for production of NAB. The corrosion behaviour of austenitic stainless steel and nickel-based welded joints is also explored by Vaccari et al.[17], where key factors for maintaining joint integrity over time of underwater wet welding is presented. Rapid solidification in welding and additive manufacturing (AM) often leads to metastable microstructures which could have different corrosion behaviour to the wrought alloy. Such differences in the corrosion behaviour could also be a source of galvanic corrosion which is highlighted in the paper by Wang et al.[18].

Conclusions

The research presented in the collection not only advances the understanding of marine corrosion but also emphasises the importance of interdisciplinary approaches to addressing the complex challenges posed by marine environments. The integration of material science, electrochemistry, and marine engineering highlights the multifaceted nature of corrosion prevention and emphasises pathways for translating research into industrial applications. The application of mathematical tools such as statistical analysis could also provide powerful tools for data analysis and better understanding of corrosion processes[19]. As offshore energy production, global shipping, and coastal infrastructure continue to expand, the insights provided by these studies are invaluable for ensuring the sustainability and durability of marine structures. It is hoped that this collection of research will inspire further innovation and collaboration in the field, pushing the boundaries of corrosion science and technology.

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Author contributions

P.R. and S.P. contributed equally to the writing and reviewing of the manuscript.

Competing interests

The authors declare no competing interests.