

Exploring Marine Biomineralization on the Al–Mg Alloy as a Natural Process for In Situ LDH Growth to Improve Corrosion Resistance

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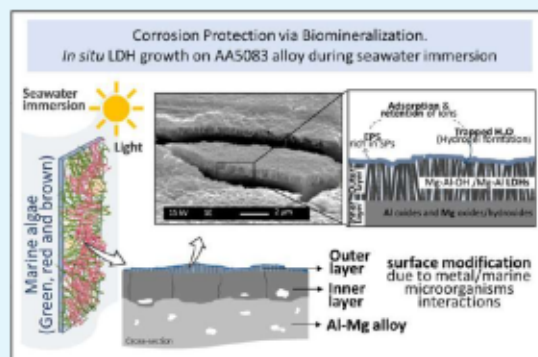
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ABSTRACT: This study provides a detailed characterization of the AA5083 aluminum alloy, surface, and interface over 6 months of immersion in seawater, employing techniques such as SEM/EDX, GIXRD, μ -Raman and XPS. The purpose was to evaluate the evolution of the biomineralization process that occurs on the Al–Mg alloy. By investigating the specific conditions that favor the in situ growth of layered double hydroxide (LDH) during seawater immersion as a result of biomineralization, this research provides insights into marine biomineralization, highlighting its potential as an innovative and sustainable strategy for corrosion protection.

KEYWORDS: aluminum alloy, in situ growth of LDH, biomineralization, marine corrosion inhibition, marine photosynthetic fouling, sulfated polysaccharides



1. INTRODUCTION

Aluminum–magnesium (Al–Mg) alloys are widely utilized in marine, automotive, and aerospace applications due to their excellent mechanical properties, low density, and inherent corrosion resistance. Despite these advantages, Al–Mg alloys are vulnerable to localized corrosion, particularly in marine environments where chloride ions and other corrosive species are present.^{1–7} Traditional methods for improving the corrosion resistance of Al–Mg alloys often involve complex and costly processes associated with significant energy consumption as well as raising environmental concerns. As a consequence, there is an increasing demand for sustainable and environmentally friendly corrosion protection strategies.^{8–11} In the last decades, bioinspired and environmentally friendly strategies have garnered attention as alternatives for anti-corrosive protection. Among these, marine biomineralization—a natural process by which marine organisms form mineralized structures—has been proven to enable the formation of protective layers on metallic surfaces, offering a promising pathway for developing new bioinspired corrosion solutions.^{12–16} Even though the studies in this field have been focused essentially on steel,^{17–28} in recent years, the research on aluminum alloys has been increasing.^{29–32} Nevertheless, the majority of the published research continues to be carried out in a laboratory environment, considering the influence of only one species of bacteria or microorganisms in the marine

biomineralization process, with very few studies being performed under field conditions.^{33,34}

Recently, with the aim of progressing in the understanding of the characteristics and properties of the marine biomineralization layer formed on the surface of Al–Mg alloy, the authors of the present article published a study that focused on the chemical and structural characterization of the surface modifications that occurred on the AA5083 alloy during 2 months of immersion in natural seawater.³⁵ It was found that the corrosion process was different according to the solar radiation, which induced a distinct development of marine fouling on the Al–Mg surfaces. In the dark (shade exposure), where the presence of hard fouling was mainly present, a single thick layer rich in Al oxides/hydroxides was formed. This layer did not show a barrier effect to Cl^- and pitting of the Al–Mg alloy was observed after two months of seawater immersion. In the case of the light side (direct exposure to sunlight), where the presence of soft fouling was mainly observed, a dual layer structure was formed in which a hydrated Mg-rich outer layer with extracellular polymeric substances (EPS) on the top was

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