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MARINE MICROBIAL INDUCED MINERALIZATION: EXPLORING MECHANISMS FOR BIOINSPIRED ANTICORROSION SOLUTIONS

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In the field of corrosion, nature has proved to be a source of inspiration for developing new green protection concepts. Over the last decades, new emerging microbial-based technologies have been studied, based on the recognition that microorganisms can influence corrosion behaviour in an advantageous way, the so-called MICI (microbiologically influenced corrosion inhibition), opening different lines of research (1-5). In particular, the process of biomineralisation on the surface of materials was recently highlighted as a promising new environmentally-friendly approach to produce protective coatings.

In this context, the ANR MICOATEC project (2020/2024, <https://micoatec.eu/>) has proposed a new approach for developing anticorrosion solutions based on a biomimetic strategy. The guiding idea of MICOATEC was to draw inspiration from the interactions between an Al-Mg alloy and the marine environment, which lead to the formation of a protective layer. The present work proposed the use of combined surface characterization techniques to understand the natural biomineralization process that develops on the surface of Al-Mg alloy when immersed in a marine biotic environment.

A very interesting finding was the identification of different layer structures developed on the alloy surface, depending on whether it is exposed to direct sunlight or shade (light and dark side). On the surface exposed to sunlight, photosynthetic micro- and macro-organisms, such as green, red, and brown algae ("soft fouling"), induce the formation of a dual layer structure, in which a hydrated Mg-rich outer layer with extracellular polymeric substances (EPS) on the top has proven to play a role in the corrosion inhibition process (figure). No localised attack was observed over the course of 6 months of immersion of the Al alloy. In contrast, surfaces exposed on the dark side, were found to be covered mainly with a "hard-fouling" composed by barnacles and calcareous tube worms, which generates a single thick layer of Al/Mg oxide containing Ca, with a less protective behaviour. Localised corrosion of the Al-Mg surface was observed after two months of seawater immersion.

To sum-up, the formation of the protective layer on the Al-Mg surface exposed to the light side in biotic conditions is shown to be related to the soft fouling developed on the metallic surface. Indeed, marine algae are a source of sulphated polysaccharides (SPs), whose hydrophilic properties enhance absorption and retention of water, favouring the formation of the hydrated Mg oxide/hydroxide rich outer layer. This outer layer has proven to play a role in the corrosion inhibition process as a barrier to the penetration of Cl^- .

In conclusion, the MICOATEC results show that the use of biomineralisation to inhibit corrosion may become an important method in the field of corrosion prevention.

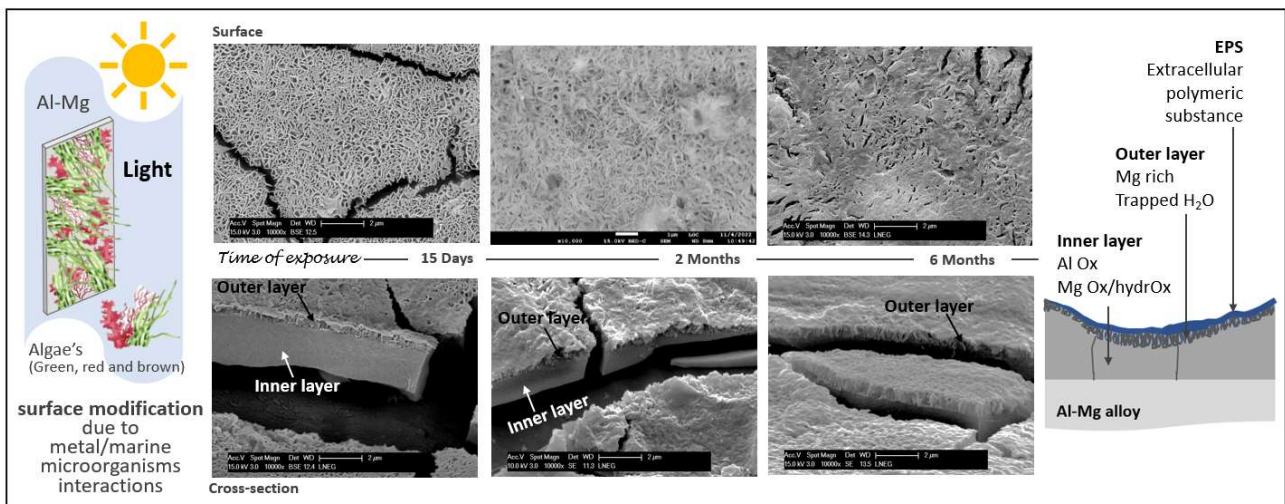


Figure. SEM observations of Al-Mg surfaces after seawater immersion on the light of exposure. Cross-section scheme based on the results of the different characterisation techniques involved in the work.

Keywords: Aluminium alloy; Corrosion inhibition; Biomineralisation; Marine algae/EPS; Bioinspired protection solution

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