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► **To cite this version:**

Régine Basséguy, M.J.F. Marques. How microorganisms can preserve metal structures. Eurocorr 2023, Aug 2023, Bruxelles, Belgium. <hal-04748637>

HAL Id: hal-04748637

<https://hal.science/hal-04748637v1>

Submitted on 22 Oct 2024

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How microorganisms can preserve metal structures

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In the anticorrosion domain, Nature is a fruitful provider of new concepts for green solutions and in this context, the recognition that microorganisms do not only accelerate corrosion but also can inhibit or protect against corrosion [1] has led to suggest microbial-based solutions for metal corrosion inhibition. In particular, biomineralization process on the surface of materials such as stones, concrete and various metals (especially steel), was recently regarded as a potential new and environmentally friendly approach to produce protective layers [2-6]. The objective of this presentation, is to show through two case studies what are the techniques and methodologies that can be used to study the impact of micro-organisms and the synergistic effect between micro-organisms and other environmental parameters in the biomineralization process.

The first case study deals with the formation of vivianite (iron (II) phosphate) on carbon steel in presence of *Geobacter sulfurreducens*, an iron reducing bacteria [4]. A thermodynamic analysis showed the importance of physical-chemical parameters such as redox potential and chemicals' concentration on the vivianite precipitation. In solution containing phosphate species, the high availability of Fe(II) ions, produced by the bacteria that reduce Fe(III), promotes the formation of a vivianite layer. This phosphate layer is believed to be formed by the combination of decreasing the redox potential in the solution and the direct electron transfer between bacteria and corrosion products.

The second case concerns the formation of a protective layer on Al-Mg alloy surface during its immersion in marine environment [5,6]. Work, carried out at three different scales (field, semi-field and laboratory), concludes that marine microbial activity has a significant effect on the evolution of the Al-Mg surface from the early stages of

exposure. This leads to the development of a protective compact layer, which thickness and nature depend on immersion time and exposure zone. In the MICOATEC French project (ANR-19-CE08-0018), the natural protection phenomena developed during the interaction process between living organisms and the metal surface is envisaged as a novel vision to develop anticorrosion solutions. These two examples can also serve as a basis for discussing and evaluating biomineralization applied to conservation and restoration of heritage artefacts.

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