

Investigation of galvanized steel biocorrosion mechanisms associated with sulfate-reducing bacteria

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Introduction

Owing to its moderate cost, corrosion resistance, and low fouling tendency, galvanized steel is a material of choice for many applications (Figure 1) [1]. Even if its theoretical service life ranges from 20 to 50 years, premature failures are frequently observed [2]. These degradations exceed predictions based only on conventional electrochemical mechanisms and are increasingly attributed to microbiologically influenced corrosion (MIC) [1],[3].

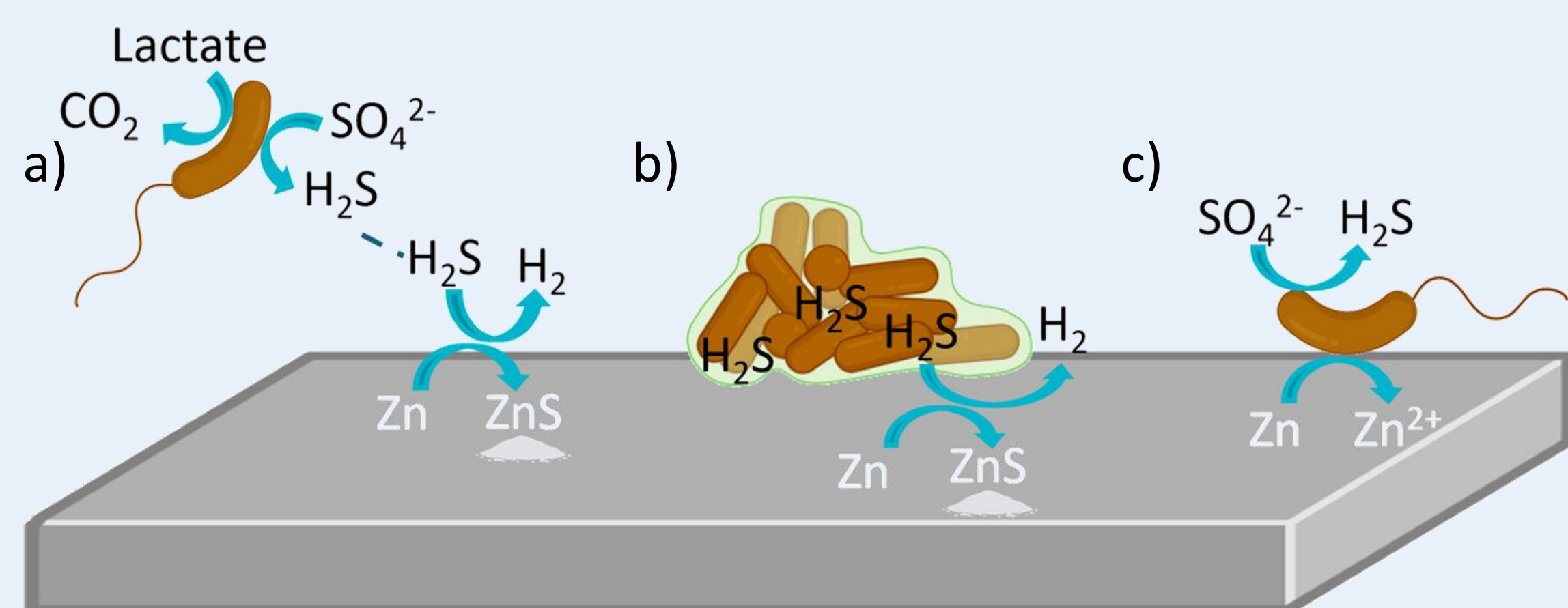


Figure 2 : Families of MIC mechanisms : a) MIC due to corrosive metabolites, b) MIC due to surface deposition and c) MIC due to extracellular electron transfers

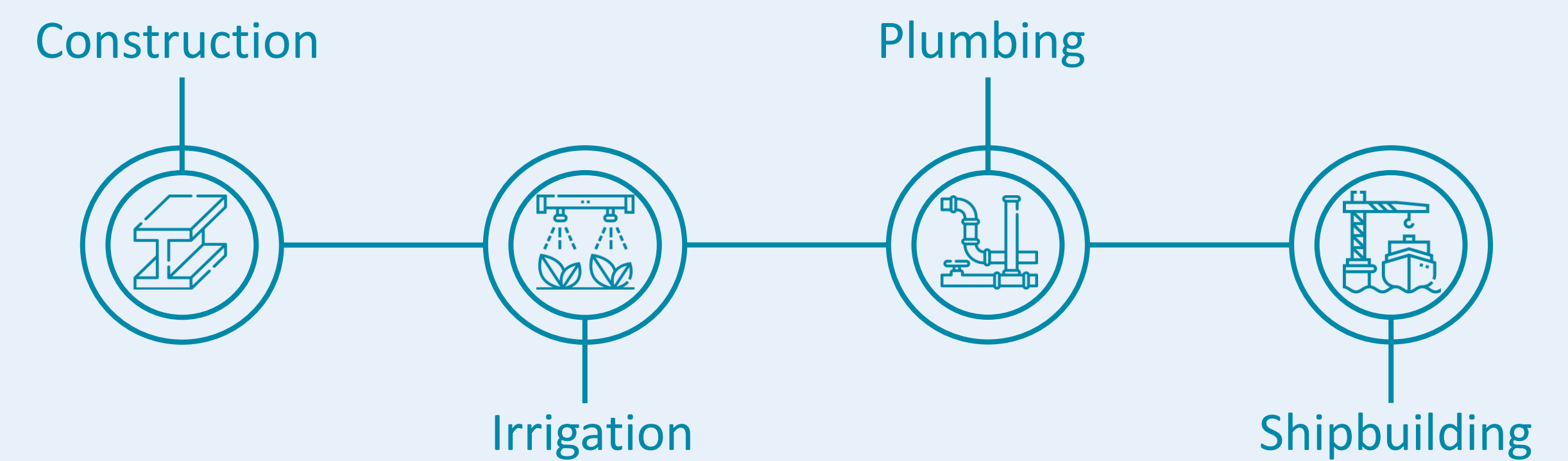


Figure 1 : Areas of application for galvanized steel

MIC, also referred to as biocorrosion, is a material degradation process in which microbial metabolic activity modifies corrosion-related electrochemical reactions (Figure 2). It is estimated to account for up to 20% of all corrosion cases worldwide [3], [4]. Among the microorganisms involved, sulfate-reducing bacteria (SRB) play a predominant role due to their ability to generate hydrogen sulfide and other aggressive metabolites. Widely distributed in aquatic environments, including cooling systems, drinking water networks, and marine settings, these bacteria are increasingly recognized as playing a role in the corrosion of galvanized steel. [1], [2], [3]. However, the underlying mechanisms of this biocorrosion remain only partially understood [1], [4].

Methodology

The BiocorGal project aims to clarify the degradation mechanisms of zinc oxides and metallic zinc in galvanized steel exposed to SRB in hydraulic environments, including drinking water and industrial cooling systems. To this end, an accelerated biocorrosion test protocol will be developed. Galvanized steel coupons will then be exposed to a known SRB strain in synthetic distribution and cooling waters under both static and dynamic conditions using closed-loop installations. Tests will be conducted on these waters in their original state and under experimentally optimized conditions to favor the development of MIC.

Biocorrosion is a complex phenomenon that arises from the interactions between a liquid medium, microorganisms and a metallic surface. Its mechanisms involve chemical, biological, and electrochemical processes, making it inherently multidisciplinary. A comprehensive study therefore involves the use of a panel of analytical techniques to characterize biofilm formation, degradation kinetics, corrosion products, and water quality evolution (Figure 3).

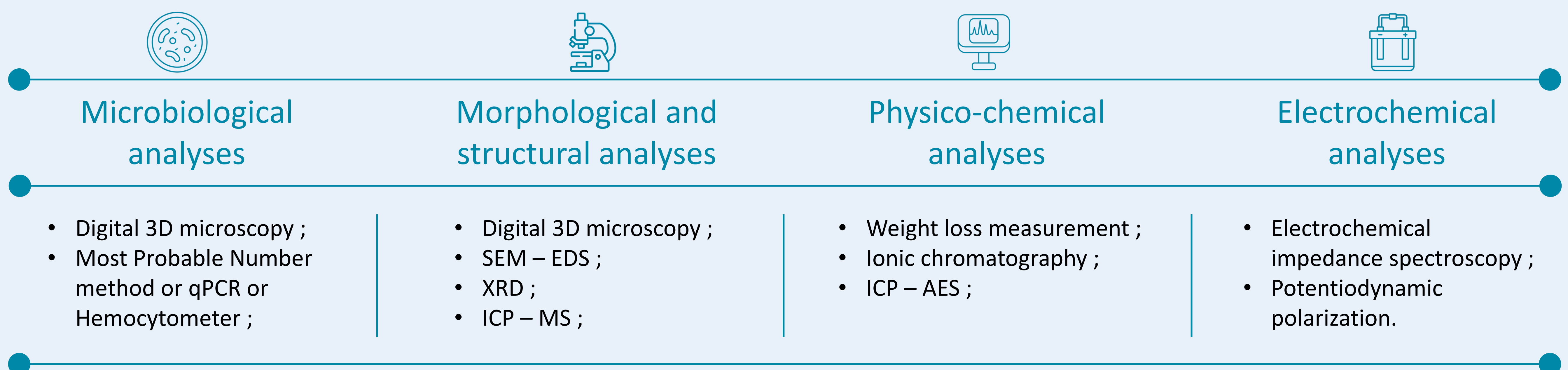


Figure 3 : Techniques to be employed for biocorrosion characterization

Expected outcomes

- The development of an accelerated biocorrosion test protocol ;
- A deeper understanding of the mechanisms driving SRB-induced biocorrosion of galvanized steel piping systems in diverse aqueous environments under both static and dynamic conditions ;
- The identification of concrete strategies to enhance galvanized steel performance against biocorrosion.

Acknowledgement

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