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Review paper

Biocorrosivity of metals: A review on Interaction, Causes, Impacts and Recent advancements

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Abstract

Biocorrosion is the deterioration of metals by the influence of microbial activity. Globally, biocorrosion is a crucial industrial problem that leads to material degradation, loss of structural framework, and economic loss. This review article summarizes the biocorrosion process, microbes involved, the impact of biocorrosion techniques to mitigate biocorrosion, and recent advancements in biocorrosion research. Several articles were surveyed to analyze the process, electrochemical interaction, byproducts of the process, and metabolism of microorganisms. Understanding this process is essential for developing effective and sustainable corrosion control strategies.

Keywords: Biocorrosion, biofilm, electrochemical reactions, metagenomic studies, ultrasonic cleaning, biocides, biosurfactants, symbionts.

Introduction

Usually, corrosion refers to the physicochemical interaction of metals with their environment, in which a series of oxidation (Cationic) and reduction (anionic) reactions occur between the metals and environmental chemicals. Biocorrosion, or microbially influenced corrosion (MIC), is defined as the deterioration of metals due to microbial activity[1]. Through various experiments, it has been shown that many metallic and non-metallic substances can be degraded by microorganisms, which can be beneficial or harmful to both humans and the environment[2].

The metals like magnesium alloy[3], Copper[4], Aluminum alloy[5], Iron-based metals which include steel and stainless steel[6,7], Titanium[8], Nickel[9]. Although the assessment cost of corrosion is challenging, the NACE International Impact Study estimated that the total global cost of corrosion was around US $2.5 trillion in 2013[10].

Microbially influenced corrosion (MIC) is estimated to contribute nearly 20-40% of the total corrosion costs[11]. The renowned Alaska Pipeline leak in 2006 was due to small 6.4mm by 12.7mm holes, which were caused by corrosive microorganisms[12].

Most of the microbes in nature live concomitantly with mixed culture biofilms. Although they are usually a thin layer, often 50-200µm, they provide a different biochemical environment for corrosion. Recent research shows that there are multiple oxidation and reduction reactions taking place under energy-deficient conditions, which lead to a multifaceted, comprehensive view of the corrosion mechanism. Scientific advancement in MIC includes met genomic analysis for profiling the corrosion-associated microbes, which sets a trend for integrating microbiology, material science, and biotechnology in corrosion research[13].

Sites for biocorrosion

Microbially influenced Corrosion (MIC) commonly occurs in the environment where bio-corrosive metals and micro organisms are present. It may be both aquatic and terrestrial habitats. Marine and Coastal areas, Industrial plants. Oil and gas industry, Water treatment plants, biomedical implants, etc.

They are usually not favored under abiotic conditions. But microbial population, temperature, pressure, concentration of chemical metabolites, pH, and surface area of metal play a major role in biocorrosion. In aggregate, the biocorrosion process provides a range of physiological activity carried by various microorganisms present in the biofilm[1].

Microbes involved in biocorrosion

Several varieties of micro-organism and are involved in biocorrosion some of them are sulfate reducing bacteria (SRB), sulfur oxidizing bacteria (SOB)[14], manganese oxidizing bacteria (MOB)[3], acid producing bacteria (APB), acidophilic archaea[15], iron oxidizing and iron reducing bacteria (IOB /IRB)[16], aerobic/ facultative biofilm forming bacteria like Pseudomonas, Enterobacter[17], fungi[18], algae[19]. By understanding the MIC mechanism at a molecular level, engineering of microbes helps to prevent corrosion rather than affecting it.

Table-1: Biocorrosive microbes.

Biocorrosive Microbes	Example
Sulfate reducing bacteria (SRB)	Desulfovibrio species
Sulfur oxidizing bacteria (SOB)	Thiooxidans, thiothrixsp
Manganese oxidizing bacteria	Leptothrixsp
Acid producing bacteria	Acetobacter
Acidophilic archaea	Methanogenic archaea
Iron oxidizing bacteria (IOB)	Thiobacillus
Iron reducing bacteria (IRB)	Shewanellaoneibensis
Aerobic/facultative biofilm forming bacteria	Pseudomonas, Enterobacter
Fungi	Aspergillusniger
Algae	Chlorella vulgaris
Symbionts (Bacteria + Algae)	Red tide algae and P.tricornutum

Process of Biocorrosion

In biocorrosion, the microorganism formsbiofilm on the metal surface and actively changes the chemical composition on the surface by forming Extracellular polymeric substances (EPS). This slimy matrix restricts the diffusion of oxygen and ions to the metal surface. This biofilm gets thicker and more complex, which creates micro- environment which becomes anionic and cationic sites for accelerating corrosion on the metal surface.

The electrochemical influence (Extracellular electron transfer) and Corrosive metabolite production (H_2S from SRP) induce the corrosion of metals. These effects lead to metal dissolution and cause localized corrosion like pitting, crevice corrosion, or cracking, which deteriorates the metal surface[20], This microbially influenced corrosion can be from bacteria, fungal or algae.

Biocorrosion by bacteria

The bacterial communities form a biofilm layer and produce corrosive metabolites like sulfides and organic acids, which change the chemical present on the metal surface and enhance the electrochemical interaction between microbes and the metal surface, which in turn increases the rate of Corrosion.

The sulfate-reducing bacteria (SRB), like Desulfovibrio species, cause biocorrosion in marine pipelines. These sulfate-reducing bacteria (SRB) use sulfate ($SO^{2-}{}_4$) as a terminal electron acceptor and produce hydrogen Sulfide (H_2S). These H_2S molecules react with Fe^+ ions in steel, forming iron sulfide (FeS), and cause Corrosion on the metal surface[14].

Pseudomonas, an aerobic biofilm forming bacteria, traps corrosive agents and creates a microenvironment for biocorrosion of carbon steel in seawater, which alters surface chemistry and weight loss measurements of the metal surface in seawater corrosion[21].

Iron oxidizing and iron reducing bacteria are part of microbial communities that increase microbially influenced corrosion by oxidizing the dissolved iron on metal surfaces, forming oxides of iron, i.e., Fe^{2+}ions to Fe^{3+} ions, which leads to the formation of iron oxide, creating uneven deposits and causing localized metal degradation[16].

Biocorrosion by fungi

Fungal biocorrosion is also called myco corrosion, where fungi colonize on a metal surface, causing biocorrosion. These fungi grow on metal surfaces and produce organic acids like citric acid, gluconic acid, and most particularly oxalic acid, which reacts with metals and forms metal oxalates, which deposit on the surface. This deposition leads to visible etching, pitting, and surface deterioration of the metal. A study shows that Aspergillus Niger reacts with copper metal to form copper oxalate and Cuprite (Cu_2O), which causes biocorrosion of copper metals, forming pitting[22].

Biocorrosion by algae

The microalgae interact with the metallic surface by forming biofilm. Changing the oxygen levels, ion distribution, pH, and certain environmental conditions can induce biocorrosion. Chlorella vulgaris, an algal species, when attached to steel in artificial sea water conditions, causes biocorrosion. This process can be suppressed by using sodium hypochlorite (NaClO) in the case of "Chlorella vulgaris”[19].

Biocorrosion by symbionts

Symbiont-like microalgae with some bacteria, like Phaeodactylum tricornutum or Bacillus altitudinis, which induces biocorrosion environment on the metal surfaces and initiate the corrosion. The biocorrosion induced by the symbiotic association of red tide alga and Phaeodactylum tricornutum and Bacillus altitudinis induces biocorrosion of dissolved iron of carbon steel in the marine environment[23].

Impacts of biocorrosion

Biocorrosion speeds up the metal corrosion by forming a biofilm layer, which changes the electrochemical composition of the metal surface. When the metal samples were exposed to sea water which were inoculated with biofilm bacteria, severe corrosion pitting on the metal surface caused weakening of the metal and material loss. The study revealed that the accumulation of biofilm on metal surfaces increased the corrosion of metals[16].

Formation of Corrosive Pitts can lead to many environmental disasters. One of the major circumstances was the Aliso Canyon methane gas leak in 2015, where a massive methane leak caused a 112-day blowout releasing over 97,000 metric tons of methane, which influenced the local air pollutant levels and phytochemical reactions, which led to headaches, nausea, respiratory irritation, adverse birth outcomes, and increased regional greenhouse gas emissions in the local area. It alsoleads to contamination of soil, water, and ecosystem imbalance[24].

Typically, biocorrosion of metals reduces the flow efficiency, which increases the frequency of maintenance of pipelines, which indeed leads to the usage of higher energy and reduces the longevity of the operational system. This adds to the cleanup costs, which would be an immense loss to the industry's infrastructure.

Strategies to mitigate biocorrosion

Several strategies are involved in reducing biocorrosion. Many Conventional methods are also applied to lessen the effect of biocorrosion. Physical approaches include regular mechanical cleaning, Ultraviolet sterilization, and ultrasonic cleaning, which help in dislodging the biofilms without leaving any residues, and the fixing of specialized anti-corrosive surface coatings on metal surfaces. Zn-Ni-Cu or Zn-Ni-Cu-TiB_2 were added as surface coatings on mild steel, which decreased the level of biocorrosion on the surface of mild steel[25], altering the environmental factors like controlling temperature and pH, which slows down the metal degradation[8].

The chemical method of controlling biocorrosion is by using traditional biocides or green biocides, which act as corrosion inhibitors by preventing the formation of a biofilm layer on metal surfaces. Ginger extract was used as a green biocide to control biocorrosion of mild steel 1010 (MS) in a cooling water system[26].

Biological agents and biosurfactants are used as they reduce the adhesion of biofilmon the metal surface, which acts as an insulation around the hydrophobic layer and hinders the accumulation of corrosive microbes. Biosurfactant produced by Pseudomonas cepacia CCT 6659 was studied as a biocorrosion inhibiting agent on carbon steel specimens, which were immersed in seawater[27].

Modern biotechnology techniques for preventing biocorrosion

Biotechnology plays a major role in understanding, monitoring, and controlling biocorrosion. It aids in studying and reduces microbially influenced corrosion. Several molecular techniques, like DNA sequencing and metagenomic studies, are used to differentiate the microbes that actively cause biocorrosion and its metabolism, which enhances the biocorrosion process[28].

By genetically engineering the biofilm microbes, many beneficial engineered biofilm bacteria (ex, Engineered Bacillus subtilties) are used to inhibit the biocorrosion of metal surfaces. These genetically engineered biofilm microbes produce some antimicrobial compounds that suppress the growth of corrosion-causing microbes on the metal surface[29].

Nanomaterials and nanobiotechnology techniques are applied to biofilm microbes in order to control biocorrosion. Nano particles like ZnO are used, which actas an antimicrobial agent and suppress the formation and growth of biofilm on metal surfaces. By coating compact engineered biofilm matrix reduces the biocorrosion by preventing the attachment of Corrosive microbes on the metal surface[30].

Conclusion

In this review, biocorrosion mechanisms, microbial contributors, and recent advancements in Corrosion engineering were examined. It creates a complex interaction between environmental microorganisms and the metal surface, which leads to accelerated biocorrosion on the surface. This interaction leads to significant economic loss, safety risk, and environmental concerns across several industries worldwide. Despite recent advances, controlling the biocorrosion under real field conditions remains ambitious. Further advancement in biocorrosion by integrating monitoring technology, nanobiotechnology, and omic study would prevent the biocorrosion process. Advanced study of biocorrosion will develop sustainable strategies for biocorrosion prevention and infrastructure durability.

References

1. Beech, I. B., & Sunner, J. (2004). Biocorrosion: towards understanding interactions between biofilms and metals. *Current opinion in Biotechnology*, 15(3), 181-186.
2. Jacobson, G. A. (2007). Corrosion at Prudhoe Bay—a lesson on the line. *Materials performance*, 46(8), 27-34.
3. Yao, X., Fu, Q., Song, G. L., & Wang, K. (2025). The Biocorrosion of a Rare Earth Magnesium Alloy in Artificial Seawater Containing Chlorella vulgaris. *Materials*, 18(15), 3698.
4. Abramova, E., Shapagina, N., Artemiev, G., & Safonov, A. (2024). Microbial Corrosion of Copper Under Conditions Simulating Deep Radioactive Waste Disposal. *Biology*, 13(12), 1086.
5. Drebezghova, V., Cugnet, C., Fernandes, S. C. M., Dupin, J. C., Guignard, M., Ranchou-Peyruse, A., Ranchou-Peyruse, M., & Nardin, C. (2025). Chitosan-based coatings to prevent Nitratidesulfovibrio vulgaris influenced (bio)corrosion on aluminium alloy. *Colloids and Surfaces. B, Biointerfaces*, 253, 114751.

6. Huang, S., Bergonzi, C., Smith, S., Hicks, R. E., & Elias, M. H. (2023). Field testing of an enzymatic quorum quencher coating additive to reduce biocorrosion of steel. *Microbiology Spectrum*, 11(5), e05178-22.

7. Zhou, E., Zhang, M., Huang, Y., Li, H., Wang, J., Jiang, G., Jiang, C., Xu, D., Wang, Q., & Wang, F. (2022). Accelerated biocorrosion of stainless steel in marine water via extracellular electron transfer encoding gene phzH of Pseudomonas aeruginosa. *Water research*, 220, 118634.

8. Rao, T. S., & Feser, R. (2024). Biofilm formation by sulphate-reducing bacteria on different metals and their prospective role in titanium corrosion. *Environmental technology*, 45(13), 2575–2588.

9. Zhang, S., Qiu, J., Ren, Y., Yu, W., Zhang, F., & Liu, X. (2016). Reciprocal interaction between dental alloy biocorrosion and Streptococcus mutans virulent gene expression. *Journal of Materials Science. Materials in medicine*, 27(4), 78.

10. Koch, G., Varney, J., Thompson, N., Moghissi, O., Gould, M., & Payer, J. (2016). International measures of prevention, application, and economics of corrosion technologies study. *NACE int*, 216(3).

11. Wolodko, J., Haile, T., Khan, F., Taylor, C., Eckert, R., Hashemi, S. J., ... & Skovhus, T. L. (2018). Modeling of microbiologically influenced corrosion (MIC) in the oil and gas industry-past, present and future. In *NACE Corrosion* (pp. NACE-2018). NACE.

12. Dou, W., Xu, D., & Gu, T. (2021). Biocorrosion caused by microbial biofilms is ubiquitous around us. *Microbial Biotechnology*, 14(3), 803-805.

13. Nasser, B., Saito, Y., Alarawi, M., Al-Humam, A. A., Mineta, K., &Gojobori, T. (2021). Characterization of microbiologically influenced corrosion by comprehensive metagenomic analysis of an inland oil field. Gene, 774, 145425.

14. Shangguan, Y., Liu, M., Liu, X., Mei, K., Shi, B., Chen, H., Liao, R., & Liu, K. (2025). Sulfate-reducing bacteria-induced corrosion behavior of L415 pipeline steel in Southern Jiangxi, China. *ACS Omega*, 10(42), 49591–49601.

15. Ivanovich, N., Marsili, E., Shen, X., Messinese, E., Marcos, Rajala, P., & Lauro, F. M. (2025). Exploring the impact of flow dynamics on corrosive biofilms under simulated deep-sea high-pressure conditions using bio-electrochemostasis. *Frontiers in Microbiology*, 16, 1540664.

16. Huang, Y., Xu, D., Huang, L. Y., Lou, Y. T., Muhadesi, J. B., Qian, H. C., ... & Jiang, C. Y. (2021). Responses of soil microbiome to steel corrosion. *npj Biofilms and Microbiomes*, 7(1), 6.

17. Maji, K., & Lavanya, M. (2024). Microbiologically influenced corrosion in stainless steel by Pseudomonas aeruginosa: an overview. *Journal of Bio-and Tribo-corrosion*, 10(1), 16.

18. Floyd, J. G., Stamps, B. W., Goodson, W. J., & Stevenson, B. S. (2021). Locating and Quantifying Carbon Steel Corrosion Rates Linked to Fungal B20 Biodiesel Degradation. *Applied and environmental microbiology*, 87(24), e0117721.

19. Zhang, J., Fu, Q., & Song, G. L. (2025). The Influence of NaClO on the Biocorrosion of Carbon Steel Induced by Chlorella vulgaris in Artificial Seawater. *Molecules*, 30(17), 3636.

20. Pal, M. K., & Lavanya, M. (2022). Microbial influenced corrosion: understanding bioadhesion and biofilm formation. *Journal of Bio-and Tribo-Corrosion*, 8(3), 76.

21. Cai, D., Wu, J., Chai, K., Wang, Y., & Li, X. (2021). Microbiologically influenced corrosion behavior of carbon steel in the presence of marine bacteria Pseudomonas sp. and Vibrio sp. *ACS Omega*, 6(5), 3780–3790.

22. Zhao, J., Csetenyi, L., & Gadd, G. M. (2020). Biocorrosion of copper metal by Aspergillus niger. *International Biodeterioration & Biodegradation*, 154, 105081.

23. Dong, Y., Song, G. L., Zhang, J., Gao, Y., Wang, Z. M., & Zheng, D. (2022). Biocorrosion induced by red-tide alga-bacterium symbiosis and the biofouling induced by dissolved iron for carbon steel in marine environment. *Journal of Materials Science & Technology*, 128, 107-117.

24. Jacobson, M. Z. (2019). Short-term impacts of the Aliso Canyon natural gas blowout on weather, climate, air quality, and health in California and Los Angeles. *Environmental science & technology*, 53(10), 6081-6093.

25. Ali, S. I., & Ahmad, S. N. (2025). Microbiologically influenced corrosion in uncoated and coated mild steel. *Scientific Reports*, 15(1), 12629.

26. Narenkumar, J., Parthipan, P., Usha Raja Nanthini, A., Benelli, G., Murugan, K., & Rajasekar, A. (2017). Ginger extract as green biocide to control microbial corrosion of mild steel. *3 Biotech*, 7(2), 133.

27. Faccioli, Y. E. S., França, I. B., Oliveira, K. W., Roque, B. A. C., Selva Filho, A. A. P., Converti, A., ... & Sarubbo, L. A. (2025). Microbial biosurfactant as sustainable inhibitor to mitigate biocorrosion in metallic structures used in the offshore energy sector. *Coatings*, 15(8), 937.

28. Kotu, S. P., Mannan, M. S., & Jayaraman, A. (2019). Emerging molecular techniques for studying microbial community composition and function in microbiologically influenced corrosion. *International Biodeterioration & Biodegradation*, 144, 104722.

29. Lv, M., Chen, L., Tang, X., Huang, R., Du, M., Zhang, X., ... & Du, Y. (2026). Influence of Bacillus subtilis on the corrosion resistance of B30 copper–nickel alloy and the biomass-regulated mineralization mechanism. *Applied and Environmental Microbiology*, 92(1), e02286-25.

30. Ambepitiya, H., Rathnayaka, S., Perera, Y., Jayathilake, C., Ferdinandez, H., Herath, A., ... & Fernando, E. (2025). Mitigating Microbiologically Influenced Corrosion of Iron Caused by Sulphate-Reducing Bacteria Using ZnO Nanoparticles. *Processes*, 13(10), 3239.