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The Role of Sulphate Reducing Bacteria in Biocorrosion in the Oil and Gas Industry

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Short Communication

Biocorrosion, also known as microbiologically influenced corrosion (MIC) is the degradation of metallic structures caused by microorganisms either by eliciting a set of electrochemical reactions directly on metal surfaces or by releasing corrosive by-products in the environment of the metal. Various microorganisms are capable of causing this type of corrosion including bacteria, archaea, and fungi [1]. The formation of biofilms by these microbes enhances adhesion of the microbial cells to metallic surfaces and also increases their chances of survival in the adverse conditions in that environment. Biofilms are formed by different species of microorganisms, and they contain water, extracellular polymeric substances (EPS) and some inorganic compounds [2]. The process of MIC is influenced by the alteration of certain physicochemical parameters at the interface between the metal and the environment by biofilms [3] cited in Agarry, et al. [2]. Biofilm production is critical to affecting the interface by increasing the hydrophobicity and electric charge [4]. Studies have shown that the presence of water in pipes or other metallic containers increases the chances of the presence of these microorganisms that cause corrosion [5,6]. The growth of these microorganisms on metallic surfaces in the petroleum industry can lead to biofouling of petroleum products [7]. Common types of bacteria responsible for causing biocorrosion include acid producing bacteria (APB), sulphate reducing bacteria (SRB), sulphur oxidising bacteria, iron bacteria (oxidisers and reducers), and manganese oxidising bacteria. Others include bacteria that secrete organic acids, methanogens and biofilm producers [7,8]. However, the acid producing bacteria and sulphate reducing bacteria are the most prominent in the oil and gas industry [7], this paper focuses on the role and impact of the latter in corrosion in the petroleum industry. The sulphate reducing bacteria potentially have two sources of electrons in iron corrosion based on the mechanism of action: electrons from a hydrogen film on the metal surface (chemical), and electrons directly extracted from the iron (electrical) [8]. The chemical mechanism is dependent on direct contact between the SRB and the metal surface unlike the electrical pathway.

Sulphate reducing bacteria produce hydrogen sulphide during biocorrosion which is highly corrosive to metal pipes. This group of bacteria are anaerobes as they use sulphur as the terminal electron acceptor, which explains their activity on oxygen-deprived surfaces in metallic pipes, buried pipelines and storage tanks. The corrosion rates of SRB appear to differ with the composition of the extracellular polymeric substances (EPS), thus certain species of SRB may produce more corrosive products compared to others [9]. During their corrosive activities, they use hydrogen (H_2) in the reduction of sulphate (SO_4^{2}) to sulphide (S^{2-}), leading to the production of hydrogen suphide and iron sulphide [8]. Examples of SRB are *Desulfovibrio* sp., *Desulfomonas* sp. The advent of molecular methods focusing on the DNA of the microbes present in the metallic environment has led to the discovery of other groups of microorganisms, as opposed to culture-dependent methods which showed limited diversity as most organisms do not grow on laboratory culture media. These molecular or culture-independent methods include polymerase chain reaction (PCR) amplification of taxonomic and/or functional genes, metagenomics, and whole genome sequencing. It is now evident that other groups of microorganisms such as the methanogenic archaea and the acid producing bacteria present in the same environment as the SRB could increase the degree of corrosivity caused by the SRB. This is made possible due to the organic acids these organisms produce.

The mechanism of action of SRB during corrosion is the cathodic depolarization which occurs when the bacteria oxidise molecular hydrogen [7,9]. The set of reactions leading to the production of hydrogen sulphide are as follows; anodic reaction, water dissociation, cathodic reaction, hydrogen oxidation, and subsequently precipitation [9]. The cathodic depolarisation is dependent on the presence of the enzyme, hydrogenase, in the SRB species. Higher rates of corrosion have been observed to be more associated with increased hydrogenase activity and less with the cell density [9,10]. Sulphate reducing bacteria can be corrosive to steel, aluminium alloy, iron and other metallic materials; and they produce a localised corrosion which is demonstrated in any of the following ways: sharp sided rounded pits, crevice corrosion, dealloying, cracking enhanced erosion corrosion and under-deposit corrosion [7,11].

The interesting fact about microbiologically influenced corrosion is that it can also be inhibited by microorganisms in the same hydrocarbon environment, they can achieve this by either consumption of reactive oxygen or inhibition of growth of microorganisms that cause MIC [8]. This is a viable, eco-friendly and sustainable approach which needs to be explored due to its eco-friendly and sustainable nature. In view of the economic losses recorded in the oil and gas sector as a result of fouling of petroleum products and the deterioration of metallic equipment affected by MIC, it is expedient for more strategies combining current chemical control methods as well as the microbially influenced corrosion inhibitory measures. Regular and frequent checks on the combination of indices, both physicochemical and microbiological, that indicate MIC should be conducted in the oil and gas industries. This would be more effective when experts in the fields of Metallurgy, Microbiology, Chemistry, and Materials Science work at an interdisciplinary level in providing sustainable solutions in handling biocorrosion.

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