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ARTICLE

ULTRAVIOLET TREATMENT: A NEW POTENTIAL TECHNOLOGY TO MITIGATE MICROBIOLOGICALLY INFLUENCED CORROSION

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Corrosion is a natural deterioration phenomenon caused by reactions of metals with their environment. It is also a natural spontaneous process with devastating impact towards the infrastructure (Norhazilan *et al*., 2011; Yahaya, 2011). There is huge challenge to mitigate this delicate phenomenon albeit the fact that it cannot be simply eliminated altogether from the deteriorating infrastructure, although with careful steps, it can be well controlled. This process has enormous financial and safety implications for many industries, including the energy industry. According to NACE International, corrosion is the deterioration of a substance or its properties as a result of an undesirable reaction with the environment (NACE, 2000). It occurs immediately when pure metals or their alloys are exposed to water. There are four components of corrosion in general: anode (defined as the oxidation reaction where corrosion takes place); a half-reaction reduction called cathode; electrolytes such as moisture, soil, and water; and the electrical connection between anode and cathode. Corrosion mitigation typically involves the use of pipeline coatings, chemical or metabolic inhibitors, biocides, and cathodic protection. In the ISO 8044 guidelines, corrosion is defined as a “physicochemical interaction (an electrochemical nature) between a metal and its environment, resulting in changes in the properties of the metal and may often lead to function impairment of the metal, the environment or the technical system.” The material corrosion impacts can be divided into three categories: energy and materials waste, economic loss, and environmental and health impacts.

In recent years, microbiologically influenced corrosion such as sulfate-reducing bacteria (SRB) in biofilm consortia indicates the role of particular bacteria in the process of corrosion in pipelines and seawater injection systems. It is well known that bacteria can oxidize a wide variety of chemicals and use them as nutrient sources and enhance the proliferation of bacteria. Microorganisms influence corrosion by altering the chemistry at the interface between the metal and the bulk fluid through biogenic MnO_2 deposition, conversion of ferrous to ferric ions, pitting by sulphuric acid production, and degradation of corrosion inhibitors. Microbial activity in any environment occurs in the presence of water, a carbon source, an electron donor, and an electron acceptor, all of which can be present in oil pipelines (Hussain, 2011). According to Sanoglu *et al.* (1997), the petroleum production environment is particularly suitable for the activities of SRB because it handles large volumes of deaerated water. Jack *et al.* (1996) reported that MIC was responsible for 27% of the corrosion deposits on the exterior of line pipe in one survey of Nova Gas Transmission Ltd. (Calgary, Alberta) lines.

Generally, SRB have been distinguished by their ability to conduct sulfate reduction, using sulfate as the terminal electron acceptor and reducing it to sulphide (Mudryk, 2000). There are a lot of classifications of SRB genuses, and each genus may contain different species of bacteria. For example, genus *Desulfobulbus* of subgroup-2 includes *Desulfobulbus elongates* and *Desulfobulbuspropionicus*. Each different species of bacteria may have its own characteristics, mainly shape, size, capability of utilizing different substrates, and other optimum performance parameters such as temperature, pressure, and pH. However, all SRB are grouped as sulfate-reducing bacteria because of their common function of reducing sulfate. Although several new mitigation methods have emerged such as adding nitrate to promote the growth of nitrate reducers that compete with SRB for nutrients (Chintan, 2005), the recommended mitigation by most companies is biocide consumption. Biocide usage can kill planktonic bacteria or inhibit their growth at low concentrations. However, MIC bacteria will become immune to biocides when used over a period of time (Chintan, 2005). Their action is to mutate, so they are not affected by that particular biocide much the same way antibiotics become ineffective if used too often. Biocides must be rotated on a regularly scheduled basis to be effective. The process to mitigate MIC using biocides also requires all operations to stop for a moment, which is costly and wastes time. Environmental concerns associated with chemical disinfection also have led to the move from traditional chemical disinfection to mechanical procedures. Thus, a new mitigation method that is environmentally friendly and cost effective in its operation needs to be built.

Ultraviolet (UV) waves were found as one of the potential substances to be built as a non-physical inhibitor. UV light is an established technology and is a common method to disinfect bacteria at water treatment facilities. It is also used for sterilization in many industries. Most UV light is designed for disinfection or to control bacteria populations (Maxwell, 2005). According to the book *MIC: An Engineering Insight* by Reza Javaherdasthi (2008), UV can be considered another method that may have good efficiency, and it has become a promising method against soft biofilms. The key target of UV-induced damage is desoxyribonucleic acid (DNA) in a variety of organisms ranging from bacteria to human. Due to this damage, the bacteria cannot duplicate, which will disinfect bacteria colonies. Various researches have been conducted to find the effectiveness of UV light in different industries. In the water treatment industry, UV is one of the popular alternative substances to purify water besides chlorine.

Laboratory and field experiments have shown that injected ultraviolet light may be as effective a treatment for microbial control as many biocides. Ultraviolet has undergone studies for decades to discover its capabilities in various industries. Ultraviolet can be defined as a physical process in which the targeted organisms are not killed, but their genetic material (DNA) is altered so that their production is prevented. The goal of ultraviolet treatment is to attain the greatest reduction of microbes possible. Wang *et al.* (2005) have proven that ultraviolet rays are more than 99% effective in disinfecting and depressing bacteria, but the key problem is that the dosage for specific bacteria properties has not yet been researched. The bacteria in existing pipelines may reproduce, which will lead to bacteria regrowth. Therefore, the optimum properties of UV in various parameters need to be studied, especially in single and flow loops, to make sure that the UV mitigation process can achieve maximum performance in disinfecting SRB. UV is applicable without using any chemicals; hence it can keep the environment clean and safe, and it will also reliably not harm the health of personnel. It is hoped that the non-physical inhibitor device using UV will be the best substitute for biocides application in the near future.

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