Corrosion Phenomena and the Occurrences; A comment
A.I. Ayodeji, O.S.I. Fayomi 1, 2, A.A. Daniyan3, K.O. Babaremu P.O. Abioye1, O. Agboola1,
1Department of Mechanical Engineering, Covenant University, P.M.B 1023, Ota, Nigeria
2Department of Chemical, Metallurgical and Materials Engineering, Tshwane University of Technology, P.M.B. X680, Pretoria, South Africa.
3Department of Materials Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.
ibukunaina31@gmail.com, Ojosundayfayomi3@gmail.com

Abstract
Corrosion refers to the deterioration of metallic materials resulting from the reactions between the components and their environe. However, corrosion occurs every day in the human world, both in industrial operations and domestically. This happens in different ways, making it well categorized into various types. This paper has concisely reported the basic phenomenon of corrosion, its environmental effect, and the various types like a crevice, pitting, erosion, and others. The Electrochemical behavior of corrosion was also reported as reactions that include oxidation and reduction reactions; oxidation reactions increase the valence number of materials by removing particles from the material, making them positively charged. In other ways, technological advancement has provided several attempts to understand this catastrophe, providing consistent mitigating measures and control toward attaining less cost. This overview studies the electrochemical corrosion phenomena and the prospect of materials selection in curtailing the ranging challenges.

Keywords: Corrosion, electrochemical bahaviour, oxidation reaction,

1. Introduction
Corrosion occurs naturally, and is defined as the gradual deterioration, degradation and destruction of a material and its chemical and electrochemical properties due to its interaction with the environment [1]. It also refers to the physiochemical activity between the metal and its environment thus resulting in the destruction of a material and then reducing the material integrity. Most metals react differently in their functioning environments thereby making it ubiquitous. It also takes many forms as it is exposed to different aggressive environments. Due to the number of studies ongoing in investigating corrosion phenomena and transmission, testing the various means in mitigating corrosion and developing corrosion protection, our understanding of corrosion has advanced [2].

The untimely failure of strong metallic materials brought about by corrosion is a noteworthy issue of our propelled society since it affects various specialized fields where metal and amalgam segments are utilized for their structural or functional properties. Not just that, corrosion diminishes the execution and strength of parts or foundations with an exceptionally high economical cost, evaluated to 3% of the yearly GDP. Therefore, it is perceived that corrosion is so strong that it destroys the economy, waste resources and cause untimely failure of plants, equipment and components as earlier mentioned. The environment also contributes greatly to the spontaneous corrosion reaction of metal [3]. When it comes to material health and wellbeing, corrosion is a major disease and must be eliminated [4]. Although corrosion is fundamentally associated with metallic materials, but that
notwithstanding, all types of material can corrode. Ceramics also corrode through selective dissolution. In as much as it cannot be completely eliminated from existence, corrosion is a major occurrence that every individual hopes to overcome as its effect is never ever a favoring one. Lowering of the system’s Gibbs free energy has been found to be the major cause of all forms of corrosion [5]. The atmosphere where corrosion arise may be air, gas or hybrid water-based. Such conditions are referred to because electrolyte because they possess their own conductivity for movement of electrons. The corrosion cycle requires not less than two reactions in a semi-corrosive atmosphere. Such reactions are called anodic and cathodic [4]. Then metal oxidation occurs by anodic reaction and reduction occurs by cathodic reaction as seen below;

\[
\begin{align*}
M & \rightarrow M^{z+} + Ze^- \quad \text{Anodic} \\
ZH^+ + ZSO_4^- + Ze & \rightarrow Z/2 H_2SO_4 \quad \text{Cathodic} \\
M + ZH^+ + ZSO_4 & \rightarrow M^{z+} + Z/2 H_2SO_4 \quad \text{Overall redox}
\end{align*}
\]

Where;
- M = Metal
- M^{z+} = metal cation
- H^+ = hydrogen cation
- Z = valence or oxidation state
- SO_4^- = surface anion

2. Electrochemistry of corrosion and its progressive effect

Every corrosive reaction is naturally electrochemical with ferrous ions on the anodic sides iron’s surface which constitute for the anodic reaction. When oxidation occurs for the iron atoms, electrons are released with a build-up of negative charge that would prevent further corrosion or reaction from the anodic side of the metal [6]. On a corroding material, corrosion consists of a reduction reaction and oxidation reaction that generate several metallic electrons and ions. These electrons in the reduction reaction are then consumed. However, for a moist environment or atmosphere with a certain amount of moisture content in the air, the conversion of water and oxygen to hydroxide ions literally consumes the electron ions [7].

Corrosion by pitting is a local type of corrosion, which forms deep, narrow pits on the surface of the metal, thus puncturing the material over time. This usually occurs when there are inclusions on the metal surface or when the surface is rough, resulting in local failure of the passive film. It is considered that pitting corrosion is very dangerous compared to normal corrosion damage because it is difficult to predict its appearance in the design system. Passivated metals are mainly attacked by pitting corrosion, which occurs in solutions containing chlorides, iodide, etc. (Seawater is a very good example). Li et al., [8] pointed out that this type of corrosion is a dangerous form because metals are punctured without warning of signs or growth in pits. Active metals undergo pitting attacks due to local external circumstances, such as holes in the coatings.

Uniform corrosion happens when there is metal waste at the same speed, in large areas of the metal surface. Uniform corrosion is uniformly spread across the surface. It occurs when the two areas of the metal (anodic and cathodic), respectively, at the surface of the metal exchange positions that extend continuously. Uniform corrosion occurs more frequently than other forms of corrosion. In fact, these materials (metals) are exposed to the atmosphere, the soil, the aqueous medium, etc. Metals undergo uniform corrosion due to their uniform chemical composition and microstructure that allows the corrosive medium to access the
surface of the metal. The uniform corrosion rate depends on the most important parameter of the temperature, because high temperature reduces the oxygen present in the aqueous solution, which influences the rate of corrosion [9]. Careful consideration should be given to uniform corrosion, as if surface corrosion continues, the surface will become rough, leading to more dangerous types of corrosion.

Galvanic corrosion is an accelerated corrosion attack when two metallic materials having different compositions are electrically coupled or connected in the presence of corrosive conditions. It is also known as bimetallic corrosion. Apparently, different metals tend to corrode and when two different metals are in contact, the electrons go from the most reactive (anodic) to the least reactive (cathode) [10]. The formed galvanic couple has the ability to accelerate corrosion of the anode and slow down or completely stop the cathode. It is also observed that corrosion becomes the worst-case scenario when the metals are more separated from each other. A small anode zone coupled to a large cathode zone will cause a high corrosion rate as well as a high current density.

Crevice corrosion is a type where a crevice, crack or overlap of the surface of metals prevents corrosive species and oxygen from entering or leaving the formed enclosure. This leads to a rise in the corrosion rate. Due to the reduction of oxygen in the formed enclosure, rapid or fast corrosion occurs in the cracks of metallic materials. Crack corrosion occurs mainly in areas where the space is wide enough to allow the liquid to penetrate the crack and narrow enough to allow stagnation of the liquid. According to [11], oxygen being restricted in the crack, a differential aeration is established between the crack and the surface. This anodic deflection can cause the formation of very destructive ecological conditions in the crack, which is useful for the further decay of the metal. The effects of this corrosion are visible below flange joints, screw heads and lap joints; between the tube plates and their tubes in the heat exchangers [12]. It is found that welded joints are better than riveted joints.

Erosion corrosion is caused by the simultaneous action of erosion and corrosion by a rapidly flowing fluid. A higher rate of corrosion or deterioration or attack due to relative movement between the metal surface and the corrosive fluid. The rate of attack of corrosion depends on the protective film, the metallic materials and their environment, the flow velocity of the liquid and so on. Erosion corrosion occurs in closed curves, constructions and cavitation with rapidly moving liquids. Metals that are soft and easily damaged are very susceptible to corrosion. Because of the relatively high velocities between the material surface and the fluid, the corrosion formed is typical and is identified with two or multi-phase type of flow. According to [13], when precipitation of salts occurs, corrosion products are produced. The corrosion process wears out and, as a result, it is prevented from forming, which makes the surface of the metal clean and be very active.

However, corrosion rate can be controlled efficiently by adopting several methods, techniques and procedures. In engineering and science research, studies of corrosion failure have increasingly become an important aspect. In a bid to avoid further or future failure reoccurrence, identifying the forms of corrosion problem and the mechanisms involved is paramount.

Conclusion
Corrosion is a well-known problem in several industries that have certain parts of their operating systems, equipment and components made up of metallic materials. It is crystal clear from literature bank that a progressive effort to curb this problem is well notices from
the discoveries of various inhibitors and coatings that will effectively mitigate corrosion. However, it is very pertinent to have a clear understanding of the causes of corrosion, its effects on various types, and its electrochemical behaviour.

Acknowledgement
The author would like to acknowledge the research contribution from Covenant University in support of open access publication.

Reference

[1] Loto, R. T., & Loto, C. A. (2018). Corrosion behaviour of S43035 ferritic stainless steel in hot sulphate/chloride solution. Journal of Materials Research and Technology, 7(3), 231-239.

[2] Faiz, M., Zahari, A., Awang, K., & Hussin, H. (2020). Corrosion inhibition on mild steel in 1 M HCl solution by Cryptocarya nigra extracts and three of its constituents (alkaloids). RSC Advances, 10(11), 6547-6562.

[3] Olivares-Xometl, O., Likhanova, N.V., Nava, N., Prieto, A.C., Lijanova, I.V., Escobedo-Morales, A. & López-Aguilar, C. 2013. Thiadiazoles as Corrosion Inhibitors for Carbon Steel in H2SO4 Solutions. International Journal of Electrochemical Science, 8, 735 – 752.

[4] Alemayehu, T., & Birahane, M. (2014, November-December). Corrosion And Its Protection. International Journal of Academic and Scientific Research, 2(4), 1-7.

[5] Sowmya, G., Rakesh, G., & Karthik, G. S. (2017). A Review on Corrosion of Steel Structures. IJSRSET, 3(2), 414-418.

[6] M. Chigondo and F. Chigondo, “Recent Natural Corrosion Inhibitors for Mild Steel: An Overview,” Journal of Chemistry, vol. 2016, 2016, doi: 10.1155/2016/6208937.

[7] A. Cinitha, P. K. Umesh, and N. R. Iyer, “An overview of corrosion and experimental studies on corroded mild steel compression members,” KSCE Journal of Civil Engineering, vol. 18, no. 6, pp. 1735–1744, 2014, doi: 10.1007/s12205-014-0362-0.

[8] Li, Y., Wang, F., & Liu, G. (2004). Grain size effect on the electrochemical corrosion behavior of surface nanocrystallized low-carbon steel. Corrosion, 60(10), 891-896.

[9] Roy, P., Karfa, P., Adhikari, U. & Sukul, D. (2014). Corrosion Inhibition of Mild Steel in Acidic Medium by Polyacrylamide Grafted Guar Gum with Various Grafting Percentage: Effect of Intramolecular Synergism, Corrosion Science, 88, 246–253.

[10] Liu, Z., Chong, P. H., Butt, A. N., Skeldon, P., & Thompson, G. E. (2005). Corrosion mechanism of laser-melted AA 2014 and AA 2024 alloys. Applied surface science, 247(1-4), 294-299.

[11] Han, J., Zhang, J., & Carey, J. W. (2011). Effect of bicarbonate on corrosion of carbon steel in CO2 saturated brines. International Journal of Greenhouse Gas Control, 5(6), 1680-1683.

[12] Fayomi, O. S. I., Akande, I. G., & Odigie, S. (2019, December). Economic Impact of Corrosion in Oil Sectors and Prevention: An Overview. In Journal of Physics: Conference Series (Vol. 1378, No. 2, p. 022037). IOP Publishing.