Guest Editorial

Corrosion and Its Consequences

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Corrosion is the gradual deterioration of material, usually a metal, by chemical or electrochemical oxidation with their environment. It is a natural, thermodynamically favorable process. Rusting, the formation of iron oxides, is a well-known example of electrochemical corrosion, which leads to the formation of iron oxides or salts. Corrosion is not really limited to metallic material; it can also occur in nonmetallic material, such as ceramics or polymers. In this situation, the term "degradation" is more suitable than "corrosion". Corrosion degrades many desirable properties of material, such as mechanical strength, appearance, and permeability to liquids and gases, all of which negatively affect various industrial processes. The process of corrosion is strongly affected by exposure to corrosion promoters, which could be present in polluted or industrial environments, in particular acidic gases such as CO_2, SO_2 and SO_3, moisture containing salts, and elevated temperatures.

During corrosion in moist environment at a particular spot on the surface of a metallic object, oxidation takes place behaving that spot as an anode. The electrons released at the anode then move through the metal to another spot on the object and reduce oxygen at that spot in the presence of H_3O^+, which is formed due to dissolution of CO_2 from air into water under moist condition of the atmosphere. Dissolution of other acidic oxides from the atmosphere would also lead to the formation of H_3O^+. This spot behaves as a cathode. An electrochemical cell is then completed with a favourable reaction, and subsequently, the surface of the metallic object undergoes deterioration. There are different types of corrosion, namely, crevice corrosion, galvanic corrosion, high-temperature corrosion, hydrogen grooving, intergranular corrosion, metal dusting, microbial corrosion, pitting corrosion, and stress corrosion cracking. The type of corrosion and its extent depend on various factors, including the reactivity of the object, the activity of corrosion promoters in the surrounding environment and the temperature at which the object is exposed.

There are major consequences of corrosion. Among them, the cost involved in fixing damage due to corrosion, severe accidents affecting the health of humans and ultimately resulting in loss of lives, and environmental pollution due to corrosion products damaging the ecosystem are notable. Another consequence of corrosion is the failure of machines to function according to the specifications or the prescribed standards. The nuclear industry also has significant corrosion problems which are unique to nuclear reactors. Moreover, the oil and gas industry play a significant role associated with corrosion damages because crude oil and natural gas consist of various impure products which are inherently corrosive. In particular, CO_2, H_2S and moisture are highly corrosive components that frequently interact with oil and gas components. Consequently, components such as pipelines, valves and turbines are subjected to various types of corrosion.

Corrosion is thus very costly and has a major impact on the economy of nations. Corrosion cost is either direct or indirect. Direct cost includes infrastructure, utilities, transportation, and production and manufacturing; Indirect cost includes cost of labour attributed to corrosion management activities, cost of the equipment required because of corrosion-related activities and loss of revenue due to disruption in supply of product. It has been reported that the total direct cost of corrosion in the United States is approximately $276 billion per year, which is 3.1% of the nation's gross domestic product (GDP). It is estimated that the indirect cost to the end user would at least be similar to the direct cost, making the total cost of corrosion $552 billion or more. Effective corrosion inhibition methods should thus be used to mitigate corrosion damage thereby minimizing the corrosion cost.

Corrosion inhibitors used on the industrial scale are chemicals that slow down the rate of corrosion of metals and alloys when used in relatively low concentrations. Such chemicals are already in use in cooling systems, storage vessels and boilers, oil and gas pipelines, as well as in construction. Incorporation of passive fillers into organic coatings to enhance corrosion protection is another attempt to overcome corrosion. Both natural and synthetic organic inhibitors can be used as additives for corrosion protection of low-grade alloys and metals. Although the use of natural organic inhibitors is still at research scale, inorganic inhibitors including chromates, molybdates and phosphates which are widely used as corrosion inhibitors of metallic surfaces could be replaced by natural inhibitors. Organic corrosion inhibitors have electron donor atoms including N, O, P and S, which allow them to be adsorbed on the metal surface and protect the surface from corrosion. Studies on corrosion inhibition by aliphatic amines and hydrazides for various alloys have also been reported. Natural chemicals derived from plants have recently been demonstrated to have impressive corrosion resistant characteristics. Plant extracts offer many advantages because they are less expensive, easier to obtain, renewable, highly biodegradable, readily available, and environmentally friendly. Application of green corrosion inhibitors, which reduce corrosion rates with low environmental impact, has become attractive in controlling corrosion. Much research has been undertaken in recent years aimed at the development of green corrosion inhibitors from plant extracts which are promising alternatives to the hazardous conventional corrosion inhibitors.

It is a known fact that the corrosion is much enhanced when pollution is present in addition to aggressive environments, and in fact, corrosion and pollution are interdependent processes. Therefore, it is a requisite to investigate the corrosion and its consequences in industries and in other places where metallic structures and objects are heavily used and apply suitable control methods and techniques. If corrosion-inhibition technologies were used more frequently in practice, a significant fraction of corrosion cost could be reduced. Research in this area is therefore a necessity.

Prof. Namal Priyantha *obtained his BSc from the University of Peradeniya, Sri Lanka in 1982, followed by a PhD in 1990 from the University of Hawaii in USA. His research interests include the construction of low-cost electrodes for field measurements, Treatment of industrial effluents, electrochemical sensors and electrochemical detection of pesticides. He served as a senior Lecturer in the University of Peradeniya, from 1993 to 2001, and a visiting lecturer at many universities in Sri Lanka, including the College of Chemical Sciences, Institute of Chemistry Ceylon. Prof. Namal Priyantha currently serves as a Senior Professor at the Department of Chemistry, University of Peradeniya.*