

# CORROSION

## SUBPOINT:

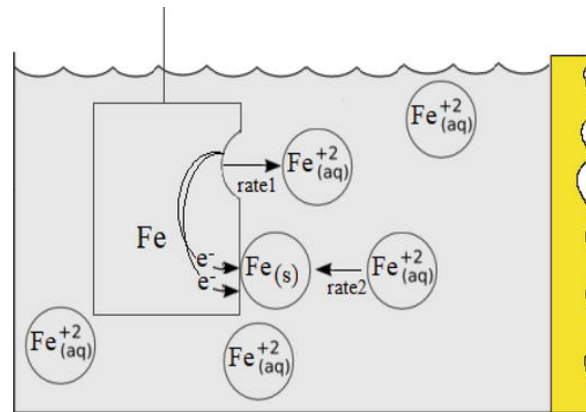
Theories of corrosion

Types of corrosion

**CORROSION:** Corrosion is defined as the reaction of a metallic material with its environment, which causes a measurable change to the material and can result in a functional failure of the metallic component or of a complete system.

**THEORIES OF CORROSION:** The metal surface undergoes an electrochemical reaction with the moisture and oxygen in atmosphere. This theory is known as electrochemical theory of corrosion. When galvanic cells are formed on different metals, and the corrosion is known as galvanic corrosion. These reactions are illustrated using the metals in the presence of electrolyte solution such as hydrochloric acid.

1) **Corrosion Reactions on Single metal:** Electrochemical reactions can be illustrated by considering the corrosion on a piece of iron, owing to surface imperfections (localized stresses, grain orientation, inclusions in the metals) or due to variations in the environment. Numerous tiny reactions may occur.



**Reaction at anode:** Oxidation takes place with the release of electrons. Positively charged iron atoms get detached from the solid surface and enter into solution (electrolyte) as positive ions.

At anode:  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$  (indicated by rough surface) The released free electrons (negative charge) pass round the external circuit.

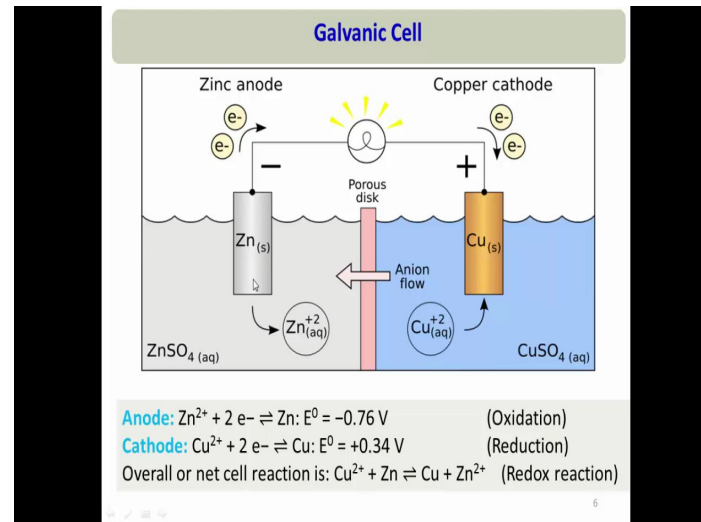
**Reaction at cathode:** reduction of constituents occurs with the taking up of electrons. The free electrons reach the cathode and react with some positively charged species such as hydrogen ions in the electrolyte solution. In the absence of acid, water itself dissociates to generate H<sup>+</sup> ions.

At cathode:  $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$  (indicated by formation of bubbles at the surface)

The amount of metal (iron) which is dissolved in the electrolyte is proportional to the number of electrons flowing, which in turn is dependent up on the potential and resistance of the metal.

## 2) Corrosion Reactions between Metals

Galvanic corrosion results from the flow of current from a more active metal (anode) to less active metal (cathode). For example, Zinc dissolves and forms an anode, while Copper (Cu) forms the cathode. These two metal form two electrodes and their presence in and electrolytic solution form a Galvanic cell.



Spontaneous reaction can occur when two electrodes are connected through an external wire.

Reactions at anode and cathode are:

**At anode:**  $\text{Zn}^{++} + 2\text{e}^-$  (indicated by rough surface) (Oxidation)

**At cathode:**  $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$  (indicated by formation of bubbles at the surface) (Reduction)

## **TYPES OF CORROSION:**

Pure metals and their alloy tend to enter into chemical union with the components of a corrosive medium to form stable compounds . corrosion can be broadly classified as follows :

1. Fluid corrosion ,general
2. Fluid corrosion, localised
3. Fluid corrosion ,structural
4. Fluid corrosion ,biological

### **1.Fluid corrosion , general :**

When corrosion is generally confined to a metal surface, its known as general corrosion. This type occurs in a uniform fashion over the entire exposed surface area at a wide range of temperatures.

a)Physicochemical Corrosion: the effects of this type are swelling, cracking, crazing, softening etc.

e.g. plastic and nonmetallic material.

b)Electrochemical Corrosion: This type of corrosion occurs at discrete points of metallic surfaces when electricity flows from cathodic area to anodic area. Metallic surface gets divided into anodic portion or cathodic portion.

### **2.Fluid corrosion ,Localized:**

Fluid corrosion is most frequently observed on different locations in a material. It occurs in numerous ways.

I.Specific site corrosion: Mechanically weak spots or dead spots in a reaction vessel cause specific site corrosion.

II.Inter-granular corrosion: Selective corrosion the occurs in grain boundaries in a metal\alloy is called inter granular corrosion.

III.Pitting corrosion: This type of corrosion results in development of pits and cavities. They range from deep cavities to shallow depression .

IV.service corrosion: In this type, corrosion occurs in cervices because solutions are retained at such places, which takes longer time to dry out

v.Stress induced corrosion: Residual internal stress in the metal or external applied stress accelerates the corrosion.

### 3.Fluid corrosion ,Structural:

The structural (mechanical) strength is reduced on account of corrosion. This may occur when one component of alloy is removed or released into the solution.

a)Graphite corrosion: Graphite is an allotropy of carbon and occurs in gray cast iron. The metallic iron is converted into corrosive products leaving a residue of intact graphite mixed with iron corrosive products an other insoluble constituents of cast iron.

b)Dezincification: This type of corrosion is seen in brass that contains more than 15% zinc. In brass, the principle product of corrosion is metallic copper ,which may redeposit on the plant. Another mechanism involves the formation of zinc corrosion products leaving the copper residue.

### 4.Fluid corrosion, Biological:

The metabolic action of microorganism can either directly or indirectly cause deterioration of a metal. Such a process is called biological corrosion.

Microorganisms associated with corrosion are either aerobic or anaerobic. The causes of biological corrosion are:

1. Producing corrosive environment or altering environmental composition
2. Certain electrolyte-concentration cells on the metal surface.
- 3.Alterng resistance to surface films.
4. Influencing the rate of anodic/ cathodic reaction.

**REFERENCE :**1.C.V.Subramanyam 'Pharmaceutical Engineering Principles & practices' ,1st edition Vallabh prakashan Pg no. 444-448.  
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3.Dr.Ashok A. Hajare text book of ' Pharmaceutical Engineering' 1st edition Nirali prakashan Pg No. 11.12-11.19

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# PREVENTTION AND CONTROL OF CORROSION

## SELECTION OF PROPER MATERIAL

1. Corrosion should not be permitted in fine mesh wire-screens , orifices and other items in which dimensions are critical and changes are not permitted.
2. Non-metallic materials are useful and attractive from the point of view of economics and performance. These should be considered if their strength temperature design specifications are satisfactory.
3. Permissible corrosion rates are important factors and differ with equipment. Appreciable corrosion can be permitted for tanks and lines, if anticipated and allowed for thickness in its design.
4. The corrosion characteristics of chemicals and limitations of construction materials must be considered from the literature before selecting the equipment.
5. In addition, processing conditions to which the material is exposed should be considered .

## PROPER DESIGN OF EQUIPMENT

1. In designing of equipment, a number of fittings such as baffles, stiffeners, drain nozzles, location of valves and pumps should be considered. Corrosion can be minimized, if equipment designed facilitates:
2. Elimination of crevices Complete drainage of liquids Ease of cleaning Ease of inspection and maintenance.
3. A direct contact between two metals should be avoided, if they are separated widely in the electrochemical series. Otherwise they should be insulated.

## ALTERING ENVIRONMENT

Corrosion can be combated or reduced by employing the following environmental conditions. Removing air from boiler feed water prevents the influence of water on steel. Reducing aeration prevents the formation of passive oxide film in stainless steel. Pumping of inert gas into solutions prevents the contact of air or oxygen as in case of nickel based alloys. Reducing the temperature. Eliminating the moisture. Reducing the velocity or turbulence. Shortening the time of exposure.

Addition of acid media should be done as the last step, so that maximum dilution can be obtained.

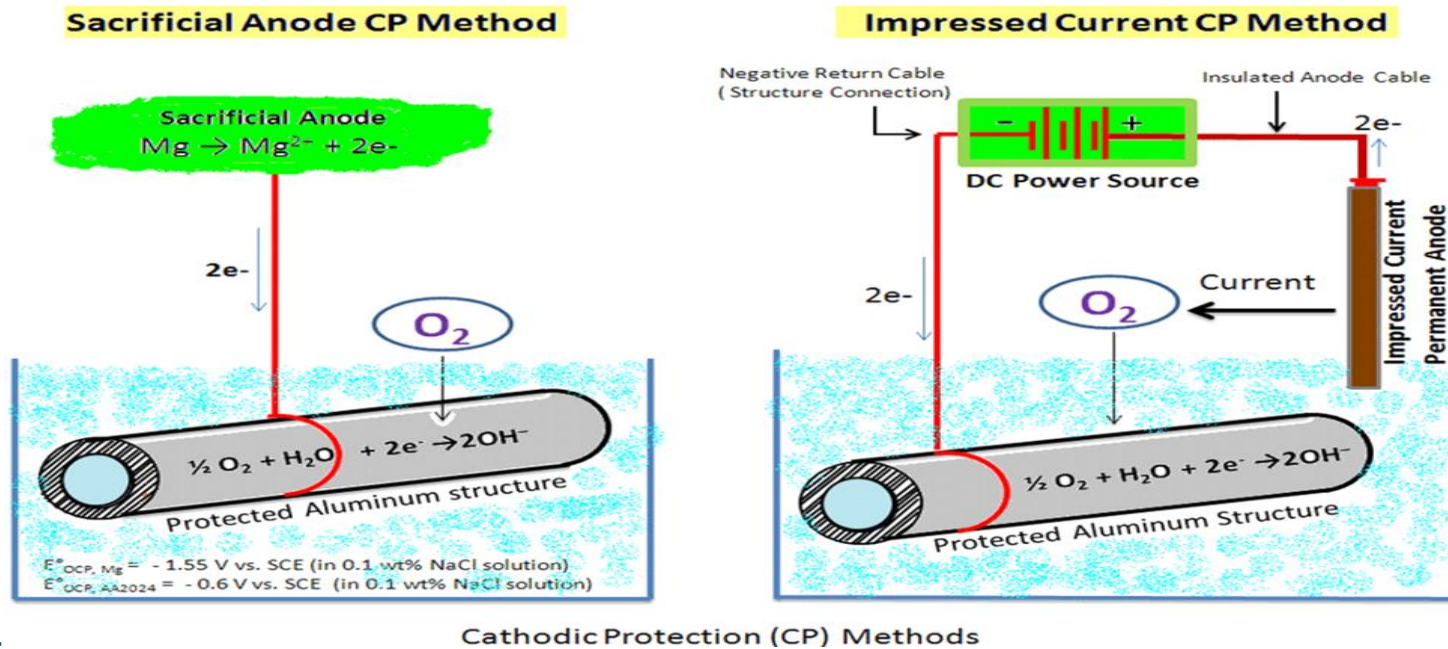
## INHIBITORS

The corrosion inhibitors are added to the environment to decrease the corrosion of metals. These forms protective films . Adsorption type, for example ,adsorbed on the metal. Scavenger type, for example, remove corrosion agents . Vapour phase type, for example, sublime or condense on metal surface .Examples of inhibitors:

Inhibitors Material protected in medium Chromates, phosphates , silicates - iron and steel in aqueous solution  
Organic sulphides, amines - iron and steel in acidic medium Copper sulphate - stainless steel in hot dil. solutions of H<sub>2</sub>SO<sub>4</sub>

## CATHODIC PROTECTION

The cathodic protection is based on the galvanic action between the metals of the plant and anode suspended in the solution. The metal to be protected is made a cathode, i.e.electrons are supplied, there by dissolution of metal is suppressed.



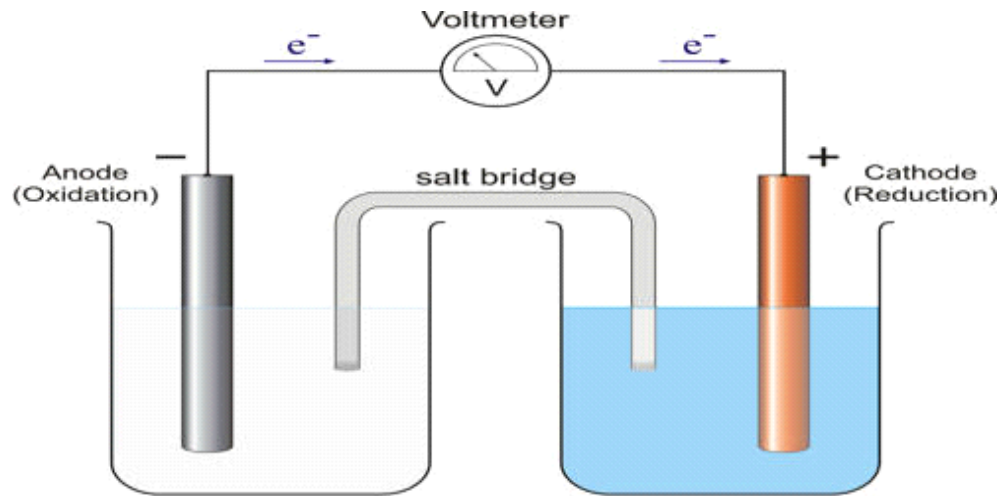
- A. Sacrificial anode method : In this method anode are kept in electrical contact with the metal to be protected (cathode). The anodes are sacrificed since it goes into the solution.
- B. Impressed EMF Method: This is also known as applied current system, i.e., external voltage is impressed between tank and electrodes. The negative terminal of power supply is connected to the material to be protected. Therefore, the natural galvanic effect is avoided and the anode is maintained positive .Since electrode is not consumed, any conducting material, metal or non-corrodible alloys can be used.

**ADVANTAGES :** This method is used for large tank to store mild corrosive liquors. In these cases, mild steel is used with negligible corrosion . cathodic protection method is simple and most effective. It is inexpensive. It enables the use of cheaper material for plant construction.



DISADVANTAGES : Corrosion cannot be reduced to zero.

**ANODIC PROTECTION:**



In the method a predetermined potential is applied to the metal specimen and the corresponding current changes are observed. During the initial stage, the current increases indicating the dissolution (corrosion) of the metal. When the current reaches a critical point, passivation occurs, i.e. the oxide layer sets in a suitable oxidizing environment. The potential at critical point is called passivating potential. Above this passivating potential, the current flow decreases to a very small value called passivating current. The passivating current is defined as the minimum protective current density required to maintain passivation. At this stage, an increase in potential will not corrode the metal since the latter is in a highly passive state. For example, in case of stainless steel, titanium becomes easily passive and cannot offer cathodic protection. In such cases, the corrosion rate may be slowed down by the use of anodic current.

**ADVANTAGES :** Anodic protection requires a small current. The anodic protection method is utilized in the transportation of concentrated sulphuric acid.

**DISADVANTAGES :** Corrosion cannot be reduced to zero .This method cannot be applied for metals, which do not passivate . A proper material should be selected for a specific process based on the literature and by personal experience. The factors influencing corrosion will not only help in selecting the right kind of the material, but also suggest the processing conditions. It is equally essential to identify the type of corrosion, if it occurs. Since the theories are known. It is possible to adopt appropriate preventive measures.

**REFERENCE :**

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2. Dr. M. Senthil Kumar & Dr. Parag .A . kulkarni book of Pharmaceutical Engineering , Thakur publication . Pg. No. 255-259.
3. Dr.Ashok A. Hajare text book of Pharmaceutical Engineering, 1<sup>st</sup> edition of nirali prakashan Pg.No.11.12- 11.12.-11.19
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