

Corrosion

11

Metals (Au, Ag exception - noble metals) exist in the nature in combined states, in the form of oxides, carbonates hydroxy carbonates, sulphates etc.



Metals — during extraction are reduced. ~~to their~~

Metals when put into use are exposed in environment (dry gases, moisture, liquids etc) → The exposed metal

surface starts to decay i.e it starts converting to stable complex.

destruction / decay
of metal starts
at the surface.

Or

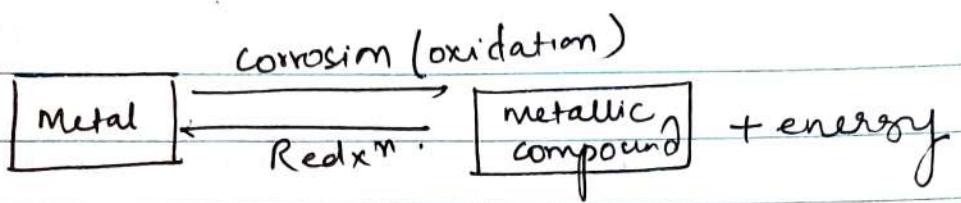
This decay

Direct chemical attack
(env).

Indirect rxn in Daniell
cell.

* Any process of deterioration / destruction and consequent loss of solid metallic material through an unwanted chemical / electrochemical method

Alternatively : Corrosion : = Reverse extraction of metal.



Higher energy

lower energy.

Corrosion and oxidation process.

Corrosion — slow process — occur @ surface of metals.

loss: destruction of metal / machine / equipment

* Dry or chemical Corrosion:

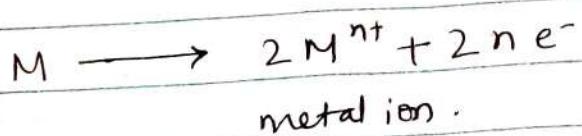


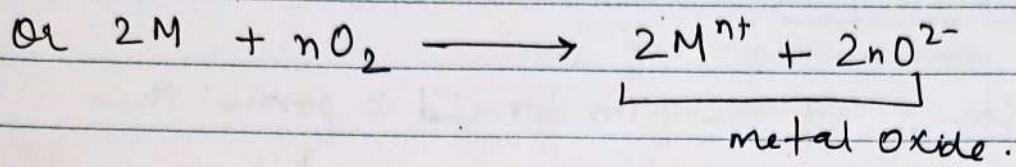
Direct chemical action of environment / atm gas. (O_2).
 H_2 , H_2S , SO_2 .

1. Oxidation corrosion : Direct action of O_2 . @ low/high temp.
 on metal usually in absence of moisture.

Alkali metal and AE metals — rapidly
 (Li, Na, K, Rb) (Be, Ca, Sr) oxidised.
 @ low temp

high temp: all metals except Au & Ag. are oxidised

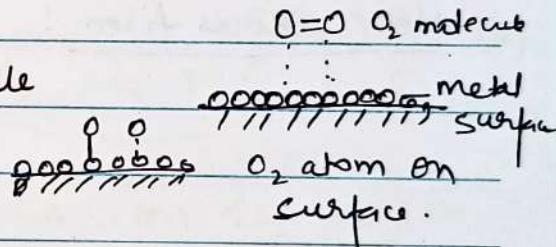




Mechanism: Oxidation occurs @ surface of metal + and the resulting metal oxide layer forms a barrier which tends to restrict further oxidation.

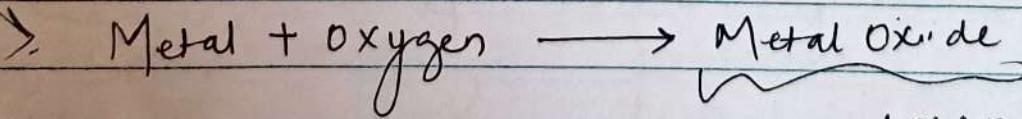
"Direct attack of atmospheric gases"

- 4 Steps : (i) Adsorption of O_2 molecule
 (ii) Dissociation of O_2 molecule



- (iii) This results in loss of e^- from metal. Metal will transfer e^- from metal to O_2 .
 (iv) formation of $im \leftarrow$ metal.

(v) metal oxide by ions (~~form~~)

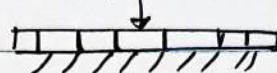


corrosion product

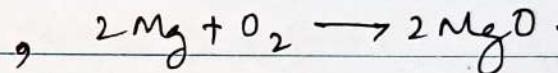
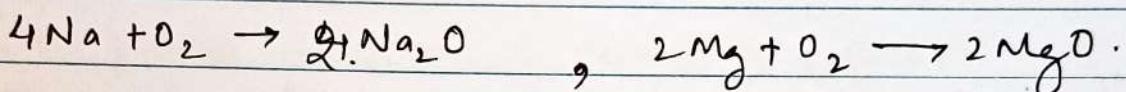
When oxidation starts, a thin layer is formed on the surface of metal. The nature of this film decides further action.

Nature of oxide film

(i) Porous film : If the film formed is porous then oxygen can enter the surface of metal and can further cause corrosion.



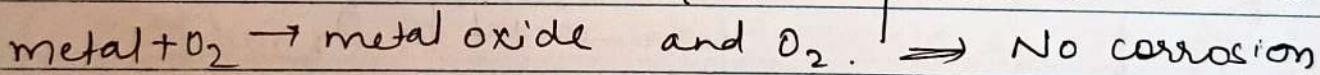
Which metal form porous film : Fe, Mg, Na, K - porous oxide



(ii) Non porous film : Stable / non porous

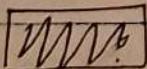
further corrosion can't be possible
Cr, Sn, Zn, Pb, Ni, Cu.

(iii) Unstable Oxide film : When the oxide film is unstable it decomposes back into the metal

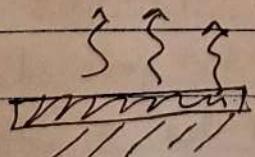


↑ decompose Ag, Au, Pb

(iv) Volatile Oxide film : Oxide formed is volatile

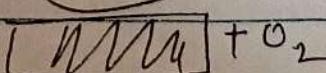
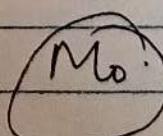
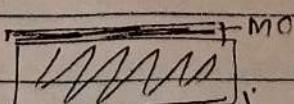
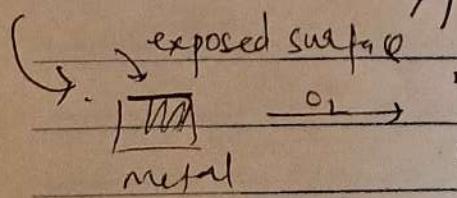


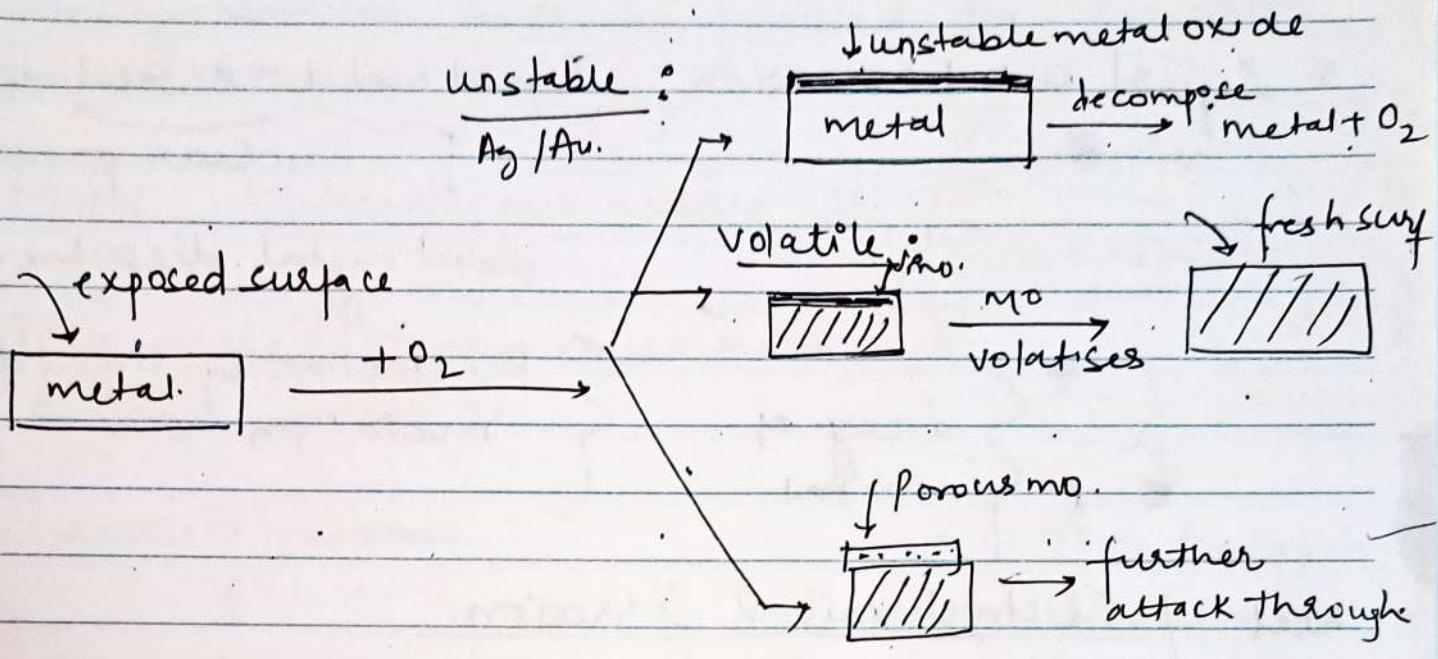
This gets evaporated.



Leading to exposure of fresh metal.

Unstable speed of evaporation very slow.



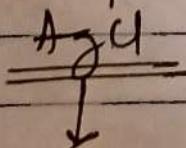


2. Corrosion by other gases. : S_O₂, CO₂, Cl₂ + H₂S

extent of corrosion depends on
chemical affinity between the
metal and gas.

Degree of attack

attack of Cl₂ on Ag.



protects metal
from further
attack.

formation of
protective
film.

(Non porous)

non protective
film

porous).

Dry Cl₂ gas on
Tin. SnCl₄

leaving metal from volatile
exposed.

3. Liquid metal corrosion : $\text{Liquid metal} \rightarrow \text{Solid metal}$
↓ nuclear power.

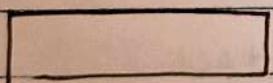
Solid metal dissolve.
Or.

* { decay of metal } { Penetration of liquid metal on solid. }

mett / Electrochemical Corrosion.

The corrosion involving the flow of electron from a particular part of metal surface called anodic area and some other part called cathodic area through a conduction ~~sojn~~ ~~cathod~~

* "when corrosion occurs in mett / moist condition.



Anode → Cathode

(i) Conducting medium.

metal + conducting liquid

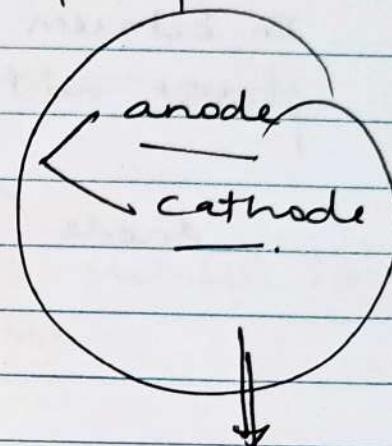
(ii) when metal of different reactivity are in contact with ~~sojn~~

following condition must be fulfilled for formation of electrochemical cell.

- Metal : Heterogeneous nature is

- These anode / cathode must have electrode potentials.

- anode \neq cathode



This helps in formation of electrochemical cell.

Connecting metal path (conducting liquid).

Two rxⁿ

Anodic Rxⁿ

Cathodic Rxⁿ

Anodic Rxⁿ

Oxidation @ anode (CORROSION OCCURS HERE)

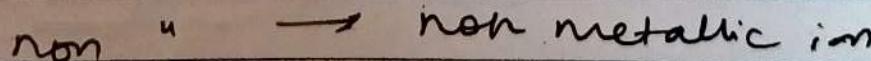
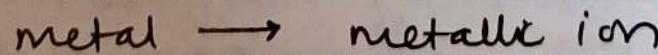
Metal will lose $n e^- \rightarrow M^{n+}$ (oxidation)

$M^{n+} \rightarrow$ dissolve in SQN (starts decaying)
(forms oxide).

Cathodic Rxⁿ: depend on environment of the rxⁿ.

↓
Electrode liberated from cathode: anode

Reduction will be accepted @ cathode and
(gain of e^-) cathodic product will be formed.



Mechanism

It involves flow of electron current between anodic and cathodic areas

Anodic Rxn — dissolution of metal as metallic ion + liberation of electron.

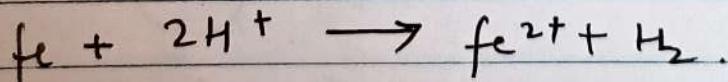


Cathodic Rxn : ~~Consumes electron~~ evolution of H
absorption of O₂.

I Evolution of H: occurs in acidic medium

Eg: Fe, The anodic rxn will be dissolution of Fe \rightarrow $Fe^{2+} + 2e^-$.

These electrons flow through the metal from anode \rightarrow cathode where H^+ of acidic soln are liberated as H_2 gas.



Anodic (alge)

Displacement of the H_2 by metal ion

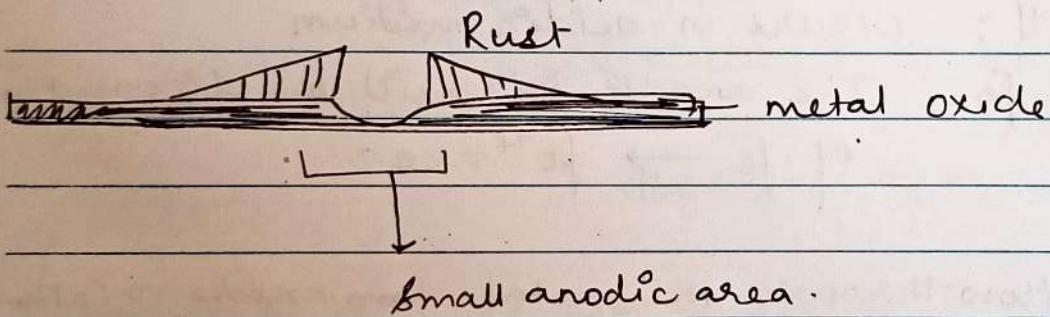
II Absorption of O_2

II : Anodic areas - smaller
cathodic areas - larger.

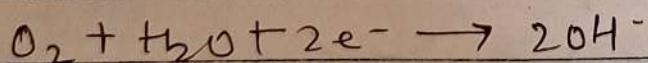
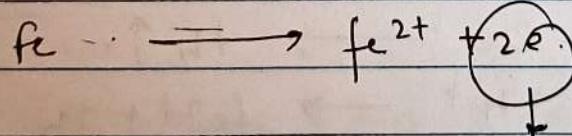
Environment Neutral : (Rusting of iron).

Surface of iron : Thin film of Iron oxide

If this develops cracks
then anodic rxn are
carried on the surface.



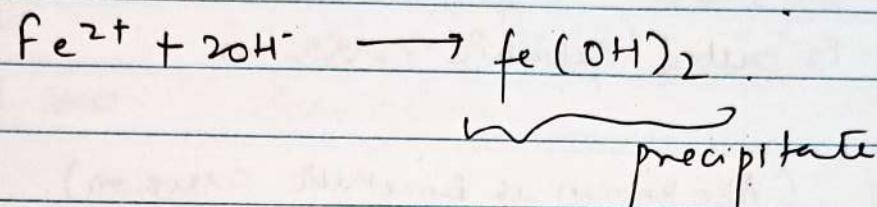
@ anodic areas : metal dissolve as ferrous ion



@ cathode

flow from anode
to cathode through
iron metal where
these e⁻ are
intercepted (blocked)
by O₂ (DO)

Cathode → ← anode.
diffuse.



If enough oxygen is present → ferrous → ferric.

If the oxygen is limited → magnetite (black).
 Fe_3O_4 .

* Rate controlling:

GALVANIC CORROSION : When two dissimilar metals are electrically connected and exposed to an electrolyte, the metal higher in electrochemical series undergoes corrosion. This type of corrosion is called galvanic corrosion.

Mechanism : (Also known as "Bimetallic corrosion").



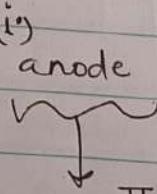
Because there is involvement of 2 metals.

The primary condition is presence of two dissimilar metals.

Also they should be widely separated in the galvanic series.

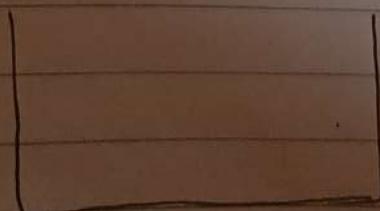
The metals should not be same.

Here we need to have an anode



The more active metal acts as anode (higher in electrochemical series)

(II) Cathode & (III) Electrolyte (V) Dissimilar metals.



GALVANIC SERIES

* Electrochemical Series:

It is also known as activity series. It organizes elements in order of increasing electrode potential values.

Mg

Zn

Galvanised Steel

Cadmium

Aluminum

Tin

Lead

Steel

Cast Iron

Copper

Nickel

Chromium

Tungsten

Brass plating

Stainless steel

Titanium

Silver

Gold

Platinum

Anode

(Least noble metals)

More active. Galvanic Series ranks metal based on their reactivity for how likely they

Higher in the series are active metal corrod़े and lower in the series are noble metals.

Steel screw in brass hardware

active metal

∴ it will corrode

Bolt and nut made of same metal.

If other metals had been there

Cathode then corrosion takes place

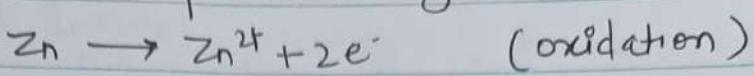
(Most noble metals)

In acidic soln : Corrosion occurs by the evolution process.

Neutral :

At Oxygen absorption occurs

The electronic current flows through the anodic metal, Zn.



to the copper is cathodic metal.

∴ Oxidation occurs @ anode and cathode is protected from the attack.

* : Galvanic Series:

Galvanic series are those series in which the arrangement of metals and non-metals are according to their nobility.

A metal high in the series is more anodic and undergoes corrosion faster than the metal below.

Galvanic series is a more practical series. The electrochemical series do not account for corrosion of all metals. It also was shown some exceptions such as Ti (its above Ag in the series but its less reactive)

Thus, galvanic series give a real and practical information about studying corrosion of metals.

* CONCENTRATION CELL CORROSION

This type of corrosion is due to electrochemical attack on the metal surface exposed to an electrolyte of varying concentration or of varying aeration. This may be due to local diff in metal ion concentration caused by temp difference / inadequate agitation / slow diffusion of metal ion (due to corrosion)

When the word cell is used, we need to identify what part are acting as anode and cathode and presence of electrolyte are essential.

If the metals are same - will there be corrosion?

↓
metal surface will be exposed to electrolyte and there will be a development of cell based on concentration of metal ion or varying concentration of O_2 .

Varying concentration of metal ion : anode and cathode areas are developed due to

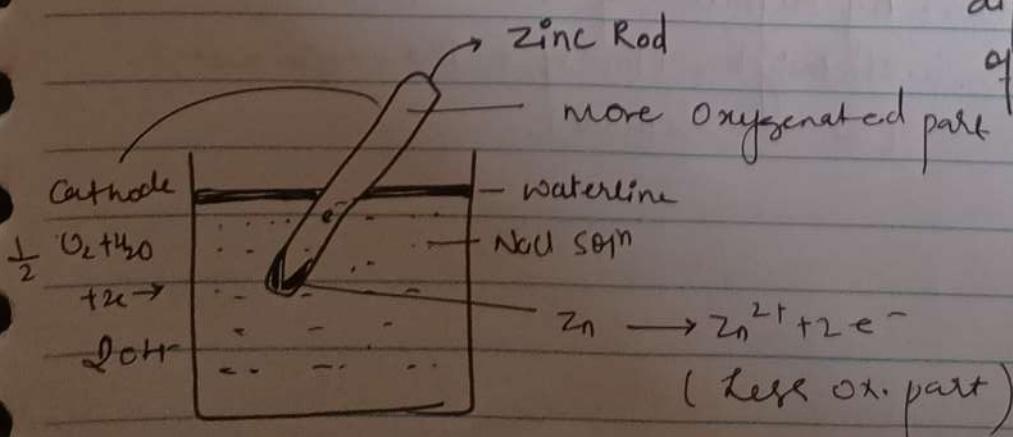
Differential aeration concentration: Most common type of concentration corrosion where one part of metal is exposed to different air concentration. This causes difference in potential. Here, poor oxygenated parts act as anode. (CORROSION ALWAYS OCCUR @ ANODE).

Differential aeration of metal causes a flow of current called differential current.

~~~~~

Differential aeration corrosion — because there is

difference in concen.  
of air



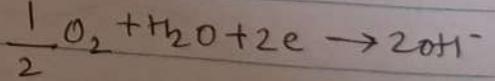
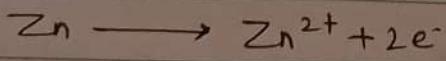
Differential aeration corrosion accounts for metals, partially immersed in  $\text{soil}$ , just below the waterline. If a metal is immersed in a  $\text{soil}$  of neutral salt say  $\text{NaCl}$  and the  $\text{soil}$  is not agitated properly, then parts above and closely adjacent to waterline are strongly aerated. They ~~be~~ act like cathode because of the easy access of  $\text{O}_2$ .

On the other hand, parts immersed to greater depth do not have access to oxygen, they act as anode ( $\text{small conc}^n$  of Oxygen).  
 $\therefore$  (Therefore) a difference of potential is created.

This difference of potential causes flow of current between two differentially aerated areas of the same metal.

Zinc will dissolve on the anodic areas

Oxygen will take up  $e^-$  on the cathodic to form  $\text{OH}^-$



Completion of circuit : By migration of ions - through electrolyte, flow of  $e^-$  through metal. (anode - cathode).

Similarly :

Iron + water droplets



areas covered by water → no access to  $O_2$



Become anodic.

Whereas the other part (freely exposed) act as cathode.

Oxygen concentration ↑es corrosion

but

It occur where concentration  
of  $O_2$  is low.

~~✓~~ Metal dissolves at less aerated areas → which further  
at

Similarly : Iron + water droplets

↓  
areas covered by water → no access to  $O_2$

↓

Become anodic.

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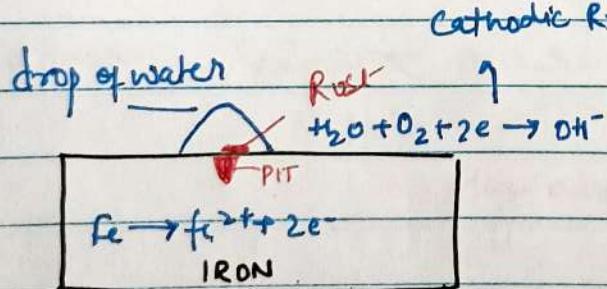
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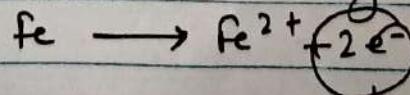
~~Metal dissolves at less aerated areas → which further act  
as →~~

Consider the following :



Let us assume that over this piece of iron a water droplet is placed. We first need to identify what part of metal is poorly oxygenated. The area under water droplet is poorly oxygenated.

The general rxn @ anode: Metal undergoes oxidation . i.e

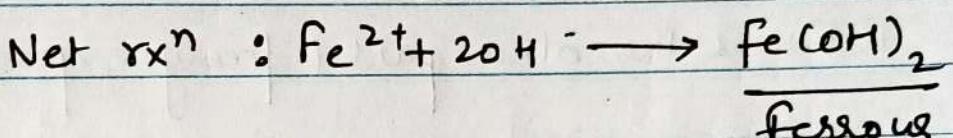
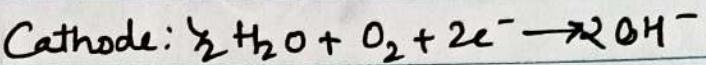


These electrons move through the metal.

We all know metal is good conductor of elect.

When it comes in contact with water and oxygen it gets reduced to form hydroxide ions. This act as cathodic rxn.

Reactions / mechanism : @ anode :  $\text{Fe} \rightarrow \text{Fe}^{2+} + 2e^-$



Rust is formed neither at cathode nor at anode.

It's formed somewhere in between.

The ~~2e~~ <sup>fe<sup>2+</sup></sup> formed after ionisation of Fe and OH<sup>-</sup> formed @ cathode diffuse towards each other to form "RUST" (CORROSION PRODUCT)

So, C.P is formed where both these products diffuse towards each other.

## PITTING CORROSION.

"Localised attack/corrosion".



Makes cavities on the metal surface.

Localised accelerated attack, resulting in the formation of cavities around which the metal is relatively "attached". Pitting corrosion results in the formation of pinholes, cavities, pits in the metal.

results after

Pitting is usually the breakdown of / cracking of protective film on the metal at specific points. This results in formation of anode and cathode. Here the anode is small and cathode is large

\* This is confined to small area.

### Reason:

Small anodic area and large cathodic area leads to drastic corrosion at anode to form PIT / HOLE.

We know, Reduction occurs @ cathode .

By absorption of  $e^-$ .

When the cathodic area is large :

Demand for  $e^-$  is large.

This demand can't be satisfied by small anodic area.

Therefore "drastic" corrosion occurs at anode in order to satisfy. (formation of pit)

### CAUSES :

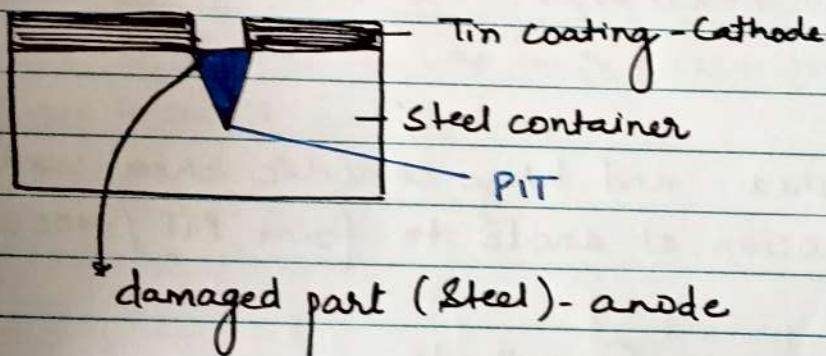
- \* When the anodic area is small and cathodic area is large.

Why this anodic area becomes small?



When there is a : damage of film

- Crack of protective film.
- Scratch
- Cuts.
- Sliding under load.
- Chemical damage.
- Surface roughness
- Turbulent flow of fluid over metal.
- Presence of impurities like sand, dust.

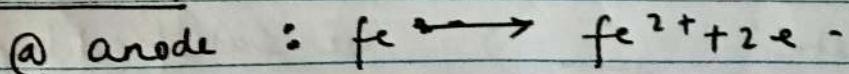


Damaged Tin coated container left out in rain

This is also the case when the protective metal oxide layer damages.

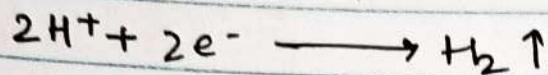
This pit is formed and fulfills demand of  $e^-$  @ large cathodic area.

### Mechanism

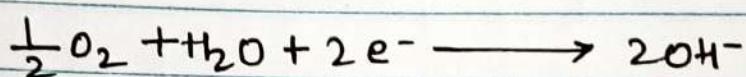


@ cathode if the rxn occur in acidic medium

The  $\text{H}^+$  ion present in the acid takes up electrons and gets reduced to liberate hydrogen.



If the rxn occur in alkaline or neutral medium: Then absorption of  $\text{O}_2$  takes place.



\* Corrosion occurs due to presence of different gases, moisture, chemicals  
in the env.

## PREVENTION OF CORROSION

Proper Designing

Using pure metal

Using metal alloys

Modifying the environment

Cathodic Protection

Anodic Protection

Use

Application

of

of coating

Inhibitors

1. Proper Designing : The design of the material should be such that even if the corrosion occurs it's uniform and does not result in intense and localised corrosion.

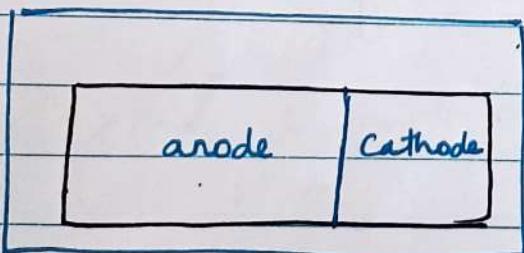
Important design principles:

- Avoid the contact of dissimilar metal in the presence of corroding soln. If this principle is not followed then corrosion is localised on more active metal. The less active metal remains protected.

- Anodic area should be large, whether there is

dry corrosion or wet corrosion,  
the effect would be limited to

anodic area (large). On the other hand if cathode is large the rate of corrosion is large



∴ We can say : large anodic area → lesser rate of corrosion.

- There should be such design which reduces direct attack of moisture. The sharp edges encourages corrosion. Blunt / curved edges is considered good design. The sharp edges should be converted to blunt design.

## 2. Use of metal Alloys :

Noble metals are corrosion resistant. Corrosion resistance of most metals are increased by alloying them with suitable elements but for max. corrosion resistance "alloy should be corrosion resistant".

Chromium → for iron and steel. (BEST ALLOYING METAL).



Self healing film. (Steel containing 13% Cr are used for surgical items, cutlery etc)

## 3. Using Pure metal :

Impurities in a metal cause heterogeneity (of non uniform composition) which lessens corrosion resistance of metal. Thus corrosion resistance may be raised by using its purity.

## 4. Cathodic Protection : Here the metal is forced to behave like cathode. Thereby corrosion does not occur.

#### 4) IMPRESSED CURRENT CATHODIC PROTECTION (ICCP)

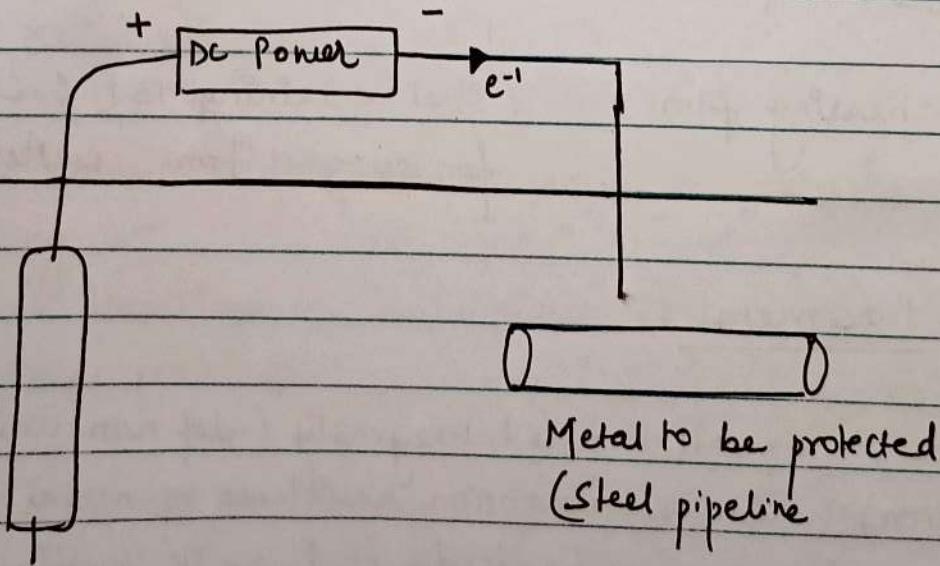
The metal to be protected is connected to an insoluble anode and current is passed using DC power source opposite to the corrosion current, so that corroding metal gets converted from anode to cathode and is protected from corrosion.

Insoluble anode / Inert Cathode : Conducting material which is not consumed.



Pt, graphite, stainless steel, mixed metal oxides, lead alloys, platinised titanium.

Mechanism :



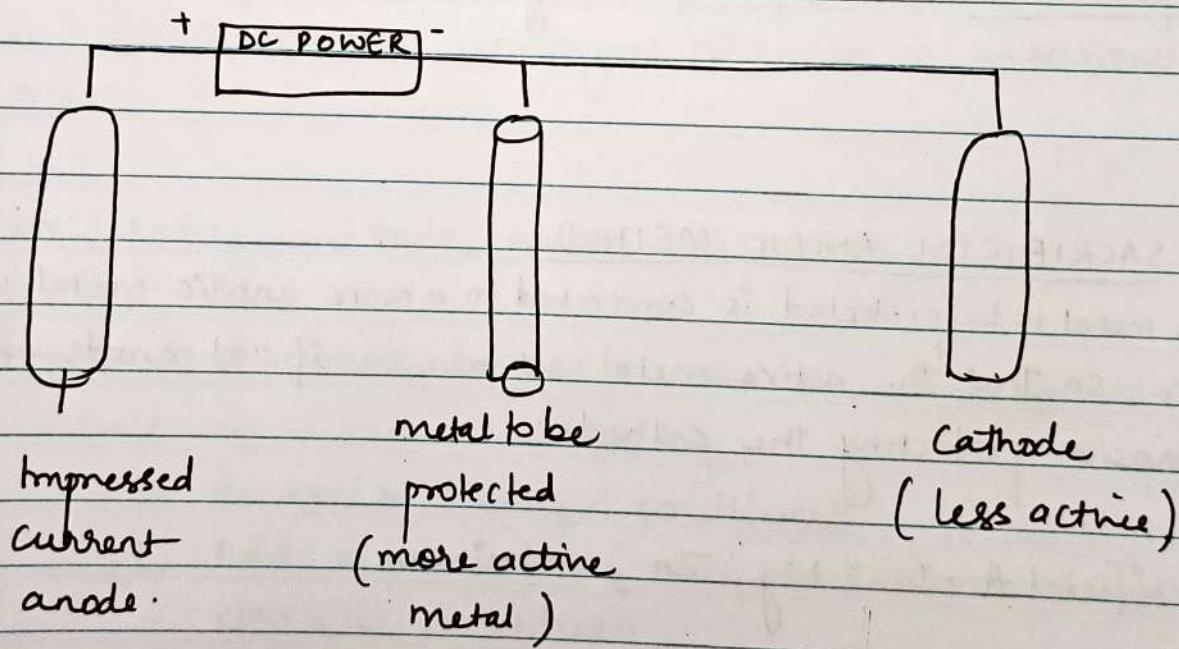
Insoluble anode

(Impressed Current anode).

Pt, Graphite.

If we need to protect the metal like steel pipeline / storage tank. It can be in contact with a dissimilar metal or it can be a separate metal pipeline. We chose another anode called Impressed current anode. The current is supplied from IC anode to the metal to be protected. (And we know that normally e's move from anode to cathode. Here by allowing movement of e's toward metal, we are making it act as cathode). This way we are preventing metal from corrosion by making it act like cathode.

If two dissimilar metals are in contact with each other:



The one which is less active act as cathode and the one which is more active act as anode.

We do not want the more active metal to undergo corrosion. So we take IC anode (which is insoluble) and pass current (DC power) which is greater than corrosion current (when two dissimilar metals were in contact with each other in the trace of corrosive medium, the current passed from anode to cathode is the natural corrosion current).

So, the more active metal act as anode earlier but later act as cathode.

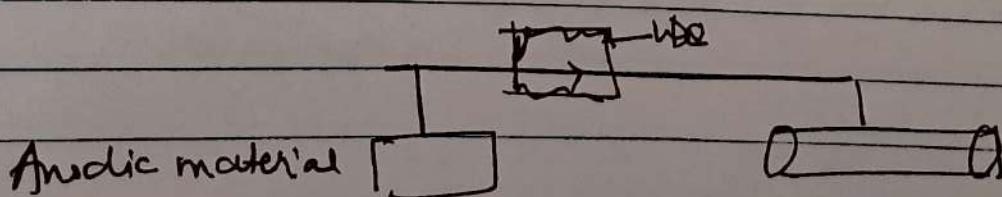
Applications : Useful for large structures for long time exposure operations.

#### (II) SACRIFICIAL ANODIC METHOD

The metal to be protected is connected to a more anodic metal with a wire, so that the active metal act as sacrificial anode and undergoes corrosion protecting the cathode.

Sacrificial Anode : Mg, Zn, Aluminium,

- Required Condition: (a) The metal to be protected (cathode) - Iron or Steel pipe or storage tank.
- (b) Sacrificial anode : Discussed above.
- (c) Electrolyte :  $\text{H}_2\text{O}$ , humidity.



\* Sacrificial cathode and anode should be in physical contact.  
Electrons move from anode to cathode.

If we want to protect the iron pipeline which is buried under the ground. We need to protect iron here. So, from the electrochemical series we will select a metal which is more anodic than iron. Zn, Mg, Fe are more anodic than Iron. We take a block of anodic metal and bury it under the ground beside the pipeline to be protected. It should be noted that both anode and cathode should be in physical contact. At anode oxidation occurs. The electron moves from anode to cathode. Here Zn / anodic material undergoes corrosion in order to protect metal.

Application: Underground tank, wires, marine structures.

5. MODIFYING THE ENVIRONMENT: The corrosive nature of environment can be reduced either by

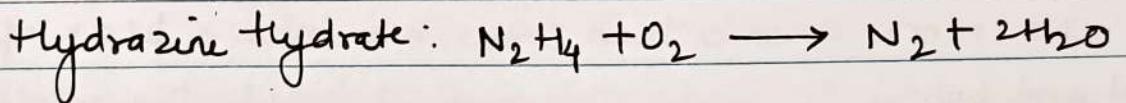
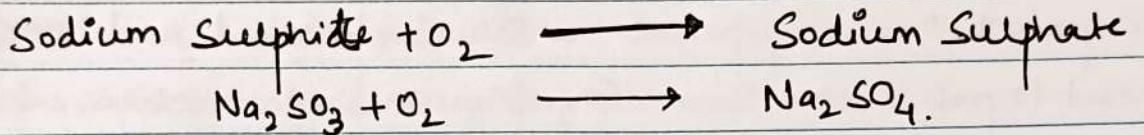
- a) Removal of harmful constituents
- or      b) Add'n of substance that neutralise effect of corrosive constituent

(i) Deaeration:

Exclusion of oxygen from aqueous env. reduces metal corrosion.

This is done by adjustment of temp,

(II) Deactivation: It involves add<sup>n</sup> of chemicals which have the capacity of combining directly with O<sub>2</sub> in the aqueous soln.



(III) Dehumidification: Reduces moisture content of air

Eg: Alumina

Silica gels

(IV) Alkaline neutralization: Prevention of corrosion by neutralising

\* Corrosion occurs due to presence of different gases, moisture, chemicals  
↑ in the env.

## PREVENTION OF CORROSION

Proper Designing

Using pure metal

Using metal alloys

Modifying the environment

Cathodic Protection

Anodic Protection

Use

of

Applicati  
of coating

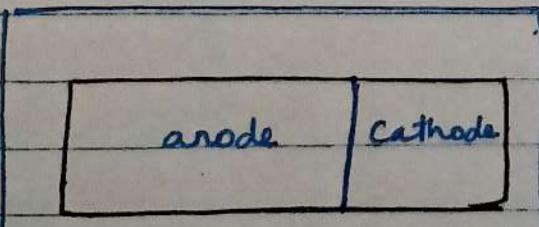
Inhibitors

1. Proper Designing: The design of the material should be such that even if the corrosion occurs it's uniform and does not result in intense and localised corrosion.

Important design principles:

- Avoid the contact of dissimilar metal in the presence of corroding soln. If this principle is not followed then corrosion is localised on more active metal. The less active metal remains protected.

- Anodic area should be large & whether there is

  
dry corrosion or wet corrosion, the effect would be limited to anodic area (large). On the other hand if cathode is large the rate of corrosion is large

∴ We can say : large anodic area → lesser rate of corrosion.

- There should be such design which reduces direct attack of moisture. The sharp edges encourages corrosion. Blunt/curved edges is considered good design. The sharp edges should be converted to blunt design.

## 2. Use of metal Alloys :

Noble metals are corrosion resistant. Corrosion resistance of most metals are increased by alloying them with suitable elements but for max. corrosion resistance alloy should be corrosion resistant.

Chromium → for iron and steel. (BEST ALLOYING METAL).

↓  
Self healing film. (Steel containing 13% Cr are used for surgical items, cutlery etc)

## 3. Using Pure metal :

Impurities in a metal causes heterogeneity (→ non uniform composition) which decreases corrosion resistance of metal. Thus corrosion resistance may be increased by increasing its purity.

## 4. Cathodic Protection : Here the metal is forced to behave like cathode. Thereby corrosion does not occur.

## Q) IMPRESSED CURRENT CATHODIC PROTECTION (ICCP)

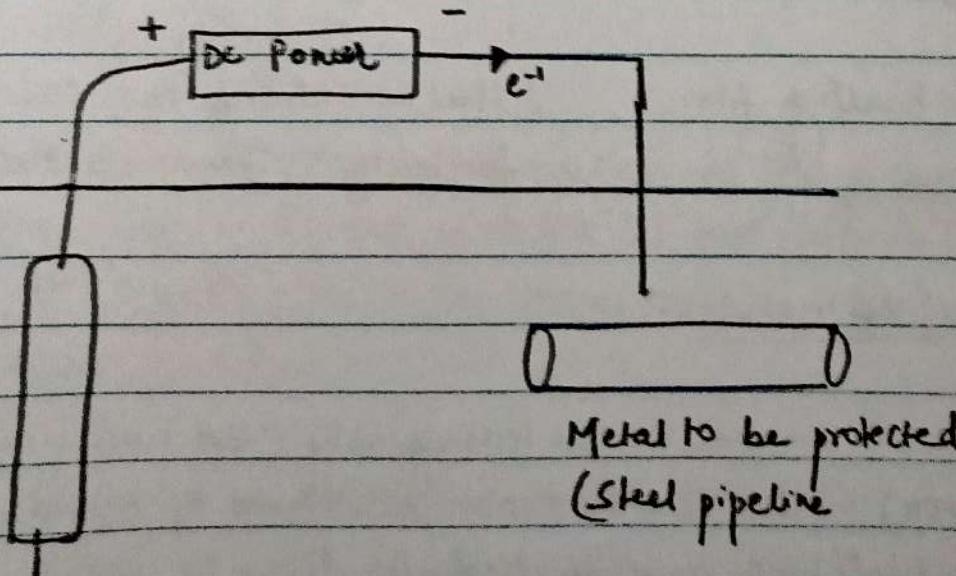
The metal to be protected is connected to an insoluble anode and current is passed using DC power source opposite to the corrosion current, so that corroding metal gets converted from anode to cathode and is protected from corrosion.

Insoluble anode / Inert Cathode : Conducting material which is not consumed.



Pt, graphite, stainless steel, mixed metal oxides, lead alloys, platinized titanium.

Mechanism :



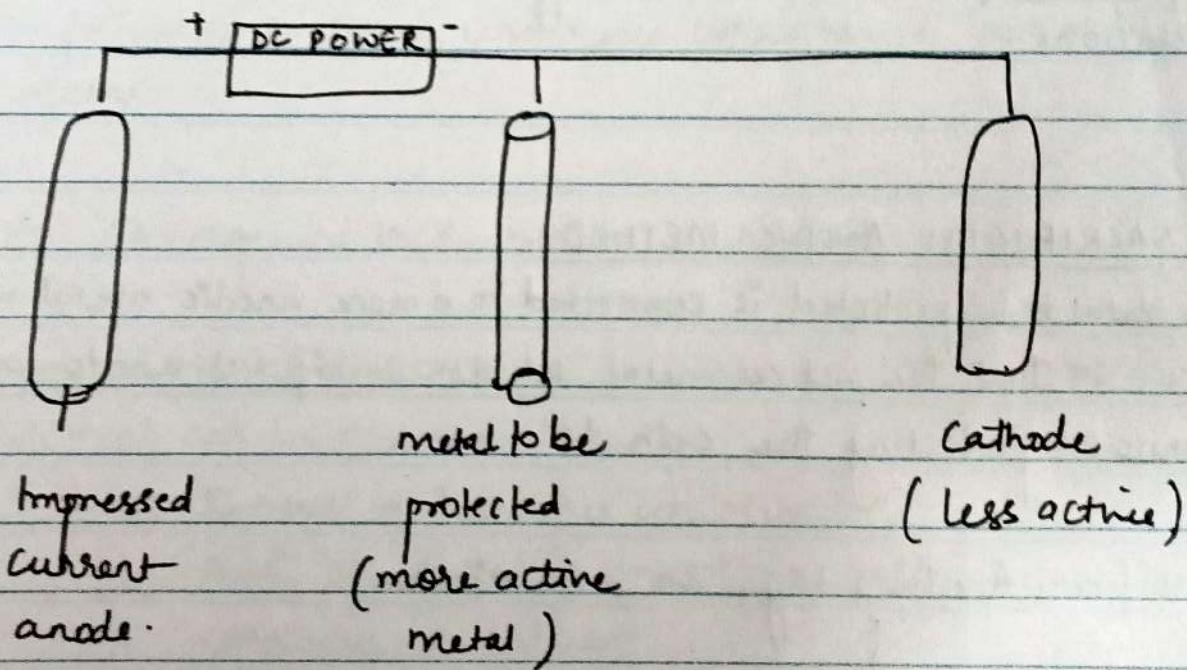
Insoluble anode

(Impressed Current anode).

Pt, Graphite.

If we need to protect the metal like steel pipeline / storage tank. It can be in contact with a dissimilar metal or it can be a separate metal pipeline. We chose another anode called Impressed current anode. The current is supplied from IC anode to the metal to be protected. (And we know that normally e's move from anode to cathode. thereby allowing movement of e's toward metal, we are making it act as cathode). This way we are preventing metal from corrosion by making it act like cathode.

If two dissimilar metals are in contact with each other:



The one which is less active act as cathode and the one which is more active act as anode.

We do not want the more active metal to undergo corrosion. So we take IC anode (which is insoluble) and pass current (DC power) which is greater than corrosion current (when two dissimilar metals were in contact with each other in the trace of corrosive medium, the current passed from anode to cathode is the natural corrosion current).

So, the more active metal act as anode earlier but later act as cathode.

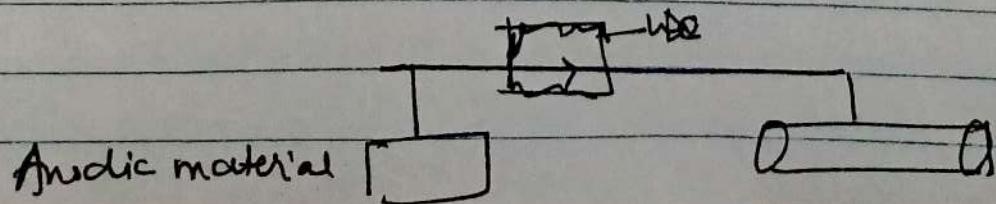
Applications : Useful for large structures for long time exposure operations.

## (II) SACRIFICIAL ANODIC METHOD

The metal to be protected is connected to a more anodic metal with a wire, so that the active metal act as sacrificial anode and undergoes corrosion protecting the cathode.

Sacrificial Anode : Mg, Zn, Aluminium,

- Required Condition : (a) The metal to be protected (cathode) - Iron or Steel pipe or storage tank.
- (b) Sacrificial anode : Discussed above.
- (c) Electrolyte : H<sub>2</sub>O, humidity.



\* Sacrificial cathode and anode should be in physical contact.  
Electrons move from anode to cathode.

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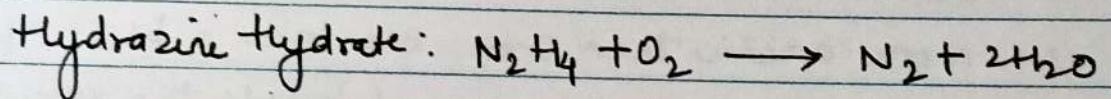
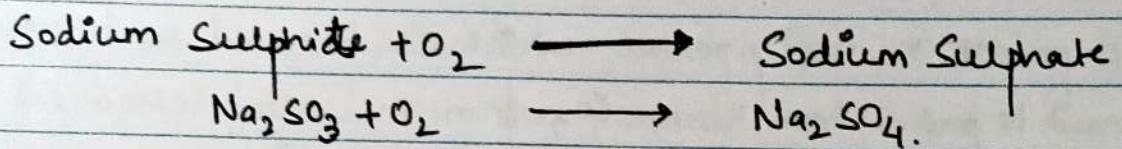
- a) Removal of harmful constituents
- or      b) Add<sup>n</sup> of substance that neutralise effect of corrosive constituent

# (c) Deaeration:

Low oxygen concentration. Exclusion of oxygen from aqueous env. reduces metal corrosion.

This is done by adjustment of temp,

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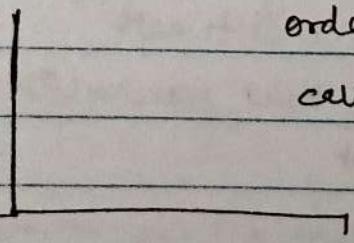
Eg: Alumina

Silica gels.

(IV) Alkaline neutralization: Prevention of corrosion by neutralising

#### CORROSION INHIBITOR

Substance added to metal surface in order to reduce the rate of corrosion are called Inhibitors.



#### Anodic Inhibitor

Chromate, phosphate, transition

metals

#### Cathodic Inhibitor

They form a sparingly soluble compound with the newly formed metal ions. That is absorbed on the metal surface.

Metal + Inhibitor  $\longrightarrow$  Sparingly soluble compound

Make a protective layer on metal surface

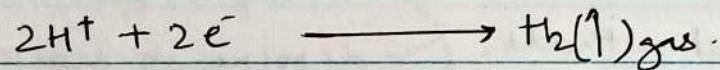
It's effective but it can be dangerous as severe local attack can occur if certain areas are left unprotected.

### Cathodic Inhibitor:

We will be inhibiting the rxn occurring at cathode.

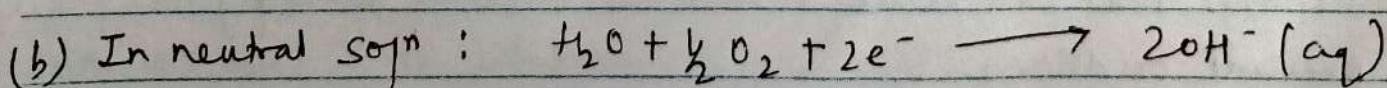
Since we know that at cathode two types of rxn happens:

(a) If it's in acidic soln then evolution of Hydrogen:



We need to slow down diffusion of  $H^+$  ion to cathode by increasing the overall voltage of  $H_2$  evolution or by adding inhibitor like amine, urea or other nitrogenated compound. These inhibitors are capable of absorbing at metal surface

(imp: Overvoltage is reduced by adding antimony or arsenic oxide. They will deposit a film of metallic arsenic thereby increasing the voltage)



Either eliminate the  $O_2$  from corroding medium or by retarding its diffusion to cathodic areas

Elimination of  $O_2$  is carried out by adding reducing agents or by deaeration.

Inhibitor used to retard are Ni, Mg, Zn. They react with hydroxyl ions forming insoluble hydroxides.

7. Application of protective coatings.

## \* GALVANISATION

Galvanisation is a metal coating process that uses Zn to protect iron or steel from corrosion.

The process involves dipping a clean iron or steel component into molten Zn, which is typically around  $450^{\circ}\text{C}$ . This ~~En~~  
The Zn coating protects the underlying metal from corrosion  
and extends its lifespan

Hot dipping: It's a process of coating the base metal (metal with higher melting point) by dipping into a bath containing molten coating metal (metal with lower melting pt.)

There are two types of hot dipping methods

Galvanising

Tinning.

It's the process of coating more active metal over less active metal.

(\* The less active metal have more standard reduction potential in the electrochemical series).

Eg: Zn over Cu, Fe, Steel.

We know that Zn is more active than these metals.

\* Galvanising is an anodic coating.

acts as sacrificial method, protecting the inner metal.

Tinning is a cathodic coating. Here coating of less active metal over more active metal.

Eg: Coating of tin over Cu, Iron, steel.

Tin doesn't undergo corrosion but Tin has more reduction potential or it's less reactive compared to Cu, Iron, Steel

## Galvanising Process :

The process of coating a base metal (metal with higher melting pt) by dipping it into a bath containing molten coating metal (metal with lower melting pt).

There are different steps involved in this process :

I

The metal has to be cleaned from organic impurities like oil, dirt etc. So, it is dipped into a caustic  $\text{soap}$  / alkaline  $\text{soap}$  and we call it as degreasing process.

II Then it's rinsed by dipping into a water bath

III It's now taken to pickling process i.e. acid dipping. A dilute acid is taken to remove all the oxide layer or scales tnt on the metal.

IV It's again rinsed by dipping into water bath.

V Now the metal is taken for fluxing. Fluxing contains ZnCl<sub>2</sub> and NH<sub>4</sub>Cl. we call it as Zn-NH<sub>4</sub>Cl flux. This is done to prevent oxidation of metal.

VI Then it's dried. When we dip the wet metal or its component into galvanising bath which is already hot causes splash. To prevent this splash metal is dried before

VII Galvanising : Here the metal is dipped into a bath where galvanization takes place. The Zn coating occurs over metal here. Zn and iron diffuses and it forms Zn-Fe alloy.

VIII It's now quenched by dipping into water. The topmost layer becomes hard. finally it's cooled.

### DEGREASING / CAUSTIC TREATMENT

(Remove dirt / oil / grease)



### PICKLING

( $\text{H}_2\text{SO}_4$  / HCl : Removes oxides and scales)



### FLUXING

( $\text{ZnCl}_2$  /  $\text{NH}_4\text{Cl}$  : Protective layer to prevent oxidation)



### DRYING

(Hot air : Reduce splash )

## TINNING

Hot dipping is a process of coating the base metal (metal with higher melting point) by dipping into a bath containing molten coating metal.

(discussed earlier too.) hot dipping Galvanising  
Tinning.

Tinning is a cathodic coating of less active metal over more active metal. e.g. coating tin over iron, steel.

Melting point of tin :  $232^{\circ}\text{C}$

The bath temp should be higher than that  
ie  $250 - 290^{\circ}\text{C}$

Tinning is a continuous process where a continuous sheet is coated with tin.

Here we have a pre treated sheet. So, over the time this pre-treated sheet can develop scales or oxides. In order to remove them, this sheet is passed through PICKLING bath. This contains dil  $\text{H}_2\text{SO}_4$  / dil Acid. Then passed to tinning bath.

In case we have a single bath:

At the bottom we have molten tin but at the top Pt will be parted (separated). At top we will have  $ZnCl_2$  flux and on other side oil/grease at the top. The bottom will have molten tin.

2 Baths: The second bath is wash pot where the temp  
is slightly lower than 1 bath. But it shouldn't be  
lower than my tin. (20° higher than my of tin)

So either we have 2 tinning baths the role of  $ZnCl_2$  flux is to dry the pickled surface and then to prepare the surface of mild steel. So that proper adhering takes place.

↓  
Passed through squeezed rollers. { The excess tin that has been coated can be removed by squeezing, and thickness of coating is adjusted.

↓  
Now it enters the second bath. The tin coated mild steel is oil coated so that it prevents oxidation of mild steel. The excess oil is removed on cooling by dusting off the excess oil using bran.

↓  
Second.

Squeeze rollers.

