# Corrosion

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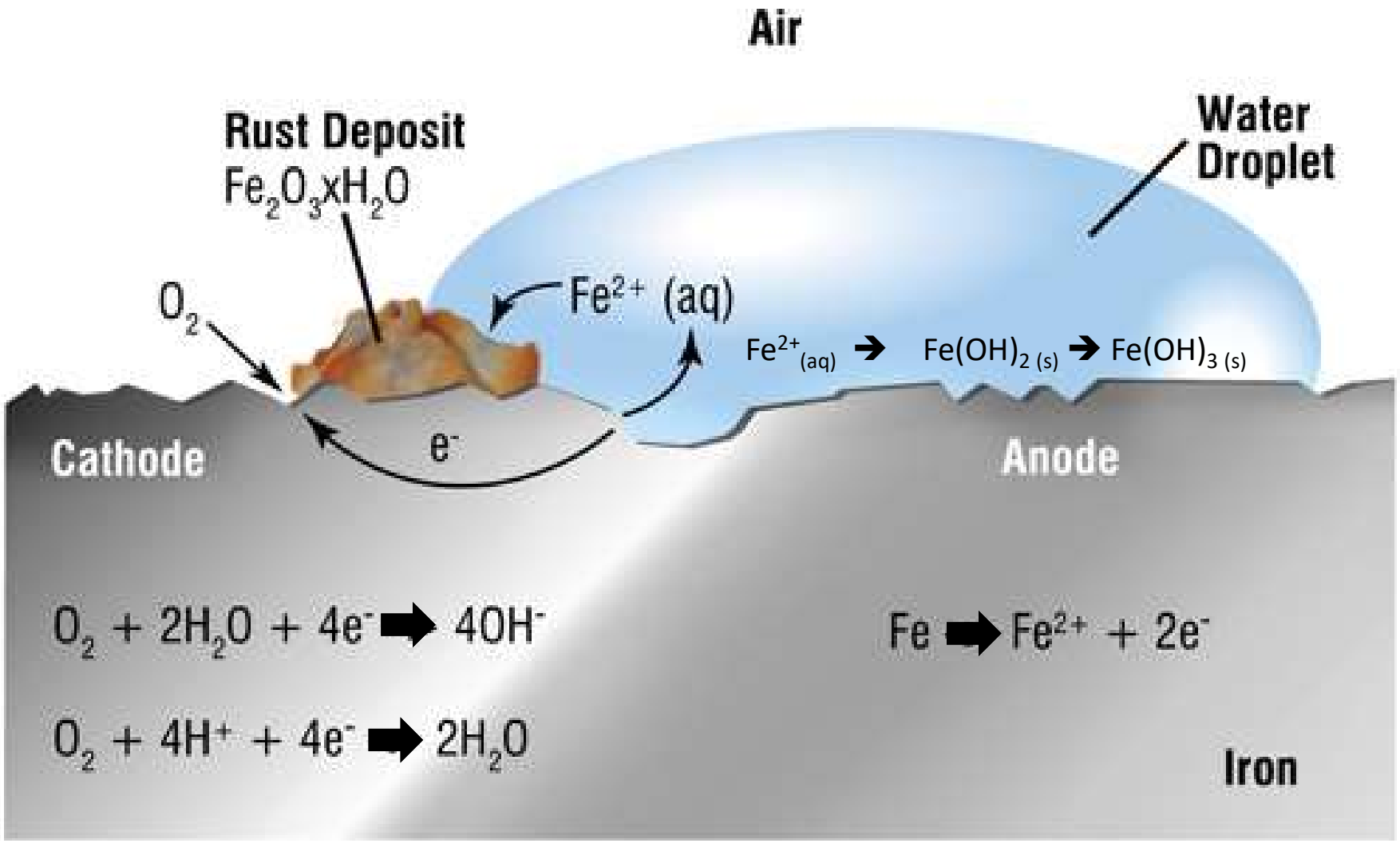
# What is Corrosion?

- Corrosion is the deterioration of metals by an electrochemical process (REDOX).
- Eg rusting of iron, silver tarnish.
- (metals to their oxides and sulfides)
- Corrosion causes enormous damage to buildings, bridges, cars ships etc.

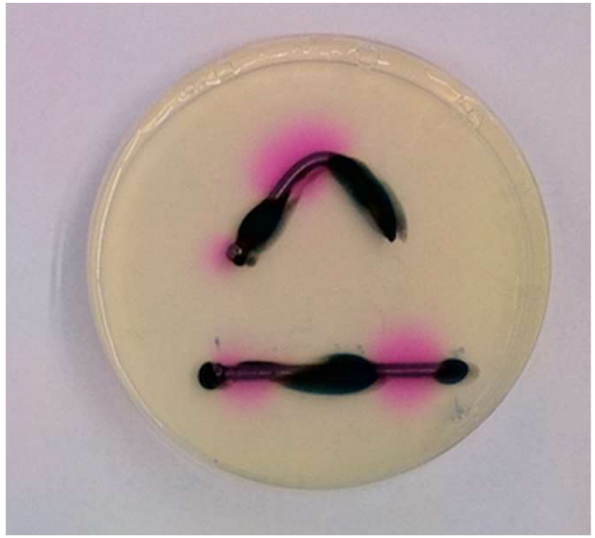
# Familiar example - Rust

- The corrosion of iron to rust is common.
- For iron to corrode $O_2$ and $H_2O$ must be present
- Very complex process but can be represented using half equations.
- The anodic and cathodic regions can be in different locations as the electrons required for REDOX can flow through the metallic iron


Air
Rust Deposit
$Fe_2O_3xH_2O$
Water Droplet
$O_2$
$Fe^{2+}$ (aq)
$Fe^{2+}_{(aq)}$ → $Fe(OH)_{2\ (s)}$ → $Fe(OH)_{3\ (s)}$
e⁻
Cathode
Anode
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
$Fe \rightarrow Fe^{2+} + 2e^-$
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
Iron

Demo – nails in agar

iron nails and a bent iron nail set in Agar with phenolphthalein (acid-base indicator) and ferricyanide (redox indicator)

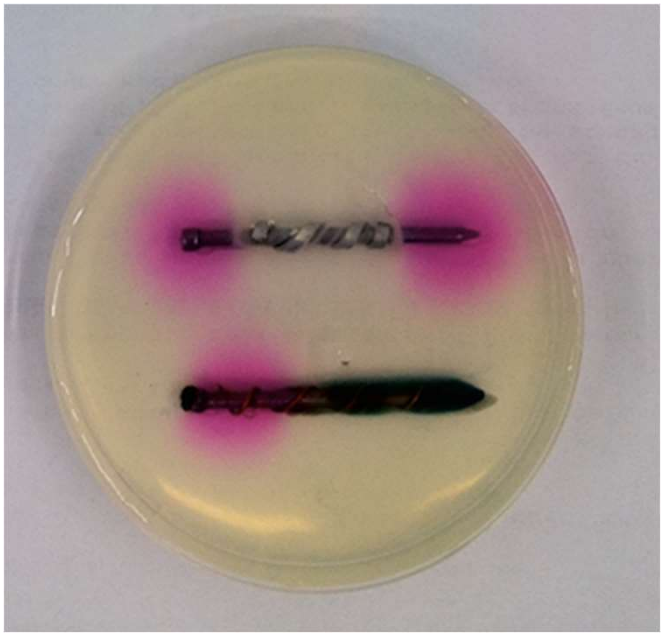


- Pink regions are cathodic (cathodes), here reaction (4) is occurring)
- Blue regions are anodic (anodes), here Fe2+ is formed through reaction (2) and the Fe2+ then reacts with the redox indicator to form Prussian blue (reaction (5))
- Nail is corroding

| | | |
|---|---|---|
| $Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$ | −2.37 V | (1) |
| $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ | −0.45 V | (2) |
| $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ | +0.34 V | (3) |
| $\frac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightarrow 2OH^-(aq)$ | +0.40 V | (4) |
| $3Fe^{2+}(aq) + 2Fe(CN)_6^{3-}(aq) \rightarrow Fe_3[Fe(CN)_6]_2(s)$ (yellow) (Prussian blue) | | (5) |

Demo – nails in agar

iron nails are wrapped in other metals – top is iron wrapped zinc; bottom is iron wrapped in copper



- Zinc/iron nail – hydroxide is forming but there is no blue so the iron nail is not corroding; instead the zinc is becoming zinc oxide and you can see a white solid on the surface of the zinc.

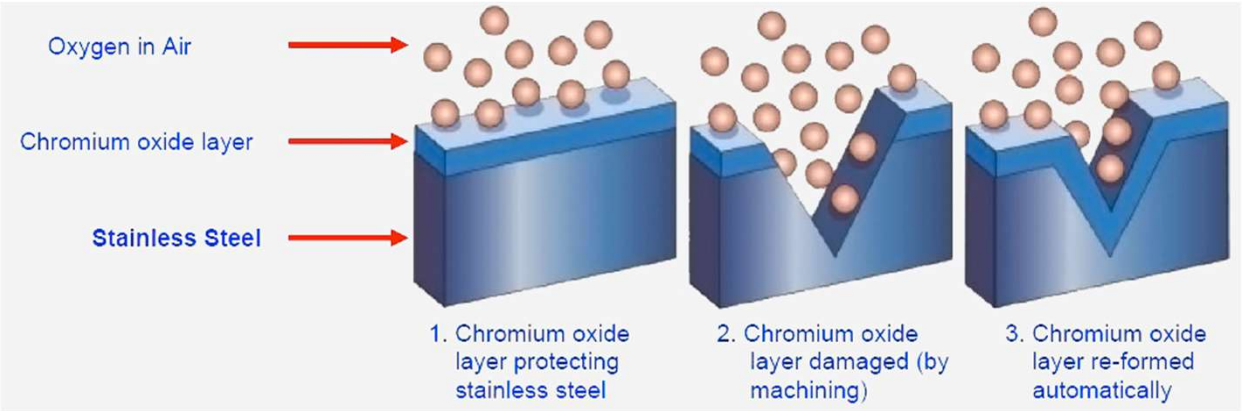
- Copper/iron nail – pink region shows hydroxide forming and the iron nail is clue all the way along while the copper stays shiny. The iron nail is corroding.

- In our class set there is also a Magnesium/iron nail, this will be pink showing hydroxide forming but there is no blue because the Magnesium is more reactive and become magnesium oxide which stops the iron nail from corroding

Corrosion Process is increased with:

- Presents of an electrolyte such as salt
- Lower pH ($H^+$ present)
- Stresses in the metal (like bends or scratches)
- When in contact with a less active metal that can become an active cathode eg tin (Sn), copper (Cu)

- The hydrated iron oxide rust is permeable to air and water.
- This allows the process of rusting to continue even under paint.
- Other metals form a corrosion product that can protect the underlying metal by preventing $O_2$ and $H_2O$ contacting the metal (also is insoluble)
- Eg Aluminium and $Al_2O_3$, Copper and $Cu_3(CO_3)_2(OH)_2$

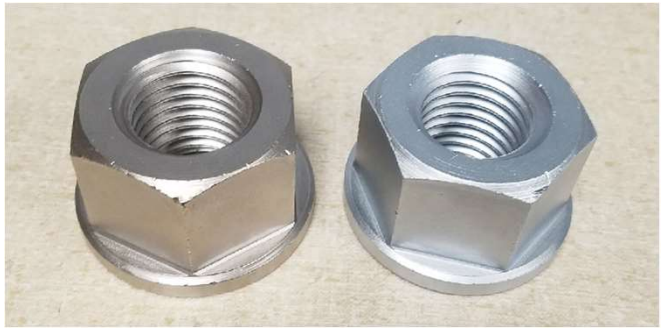


# Prevention of Corrosion

- Surface coatings (metal or non-metal)

Paint – covers metal protects from air and water, however, if scratched, pitted or dented to expose bare metal, it will rust under the paint.

Metal plating – a protective covering of another metal such as tin or zinc. These metals protect the iron and form non-porous oxide coatings.

# Metal plating if scratched:

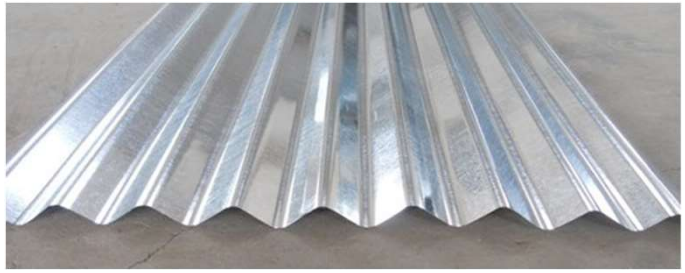
- Corrosion can occur in the case of the tin coating as the iron can act as an anode and rapidly rust:

  $Fe \rightarrow Fe^{2+} \quad 2\,e^{-} \qquad \varepsilon^{\circ}_{(red)} = +0.44V$

  $Sn^{2+} + 2e^{-} \rightarrow Sn \qquad \varepsilon^{\circ}_{(ox)} = -0.14V$

- With a zinc coating (or galvanised) the zinc is easily oxidised than iron and remains protective:

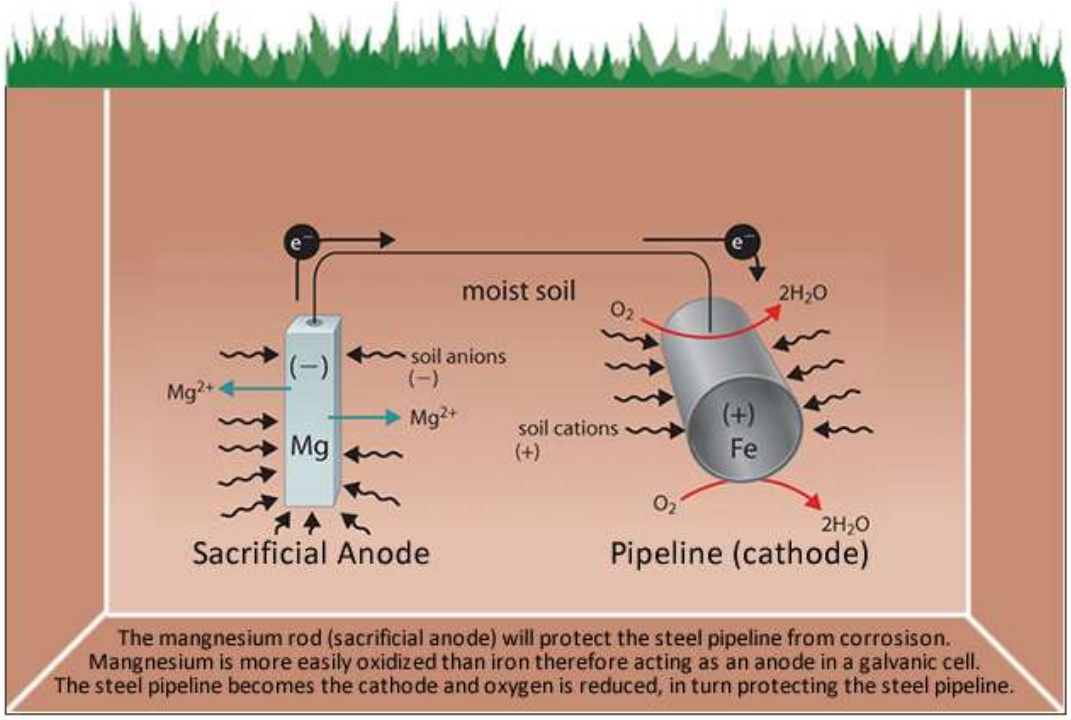
  $Zn \rightarrow Zn^{2+} \quad 2\,e^{-} \qquad \varepsilon^{\circ}_{(red)} = +0.76V$

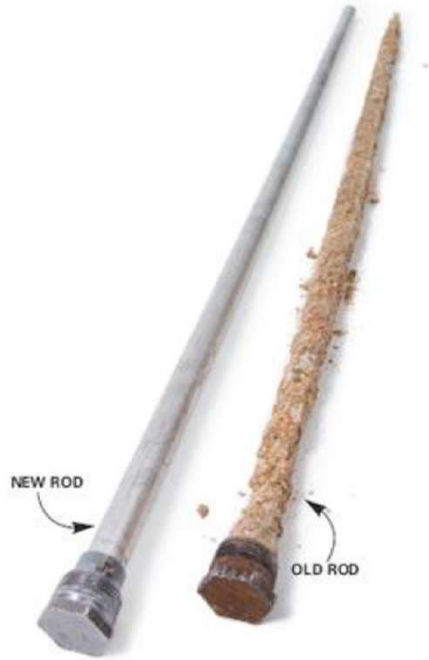


# Cathodic Protection

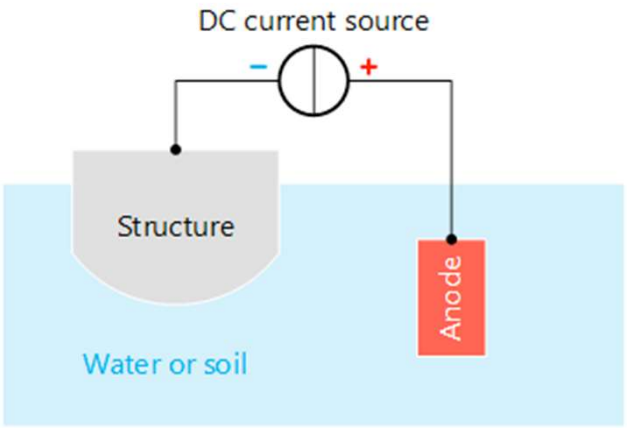
- Connecting the iron to a more reactive metal such as zinc or magnesium. An electrochemical cell forms where the more reactive metal is corroded away as the sacrificial anode.

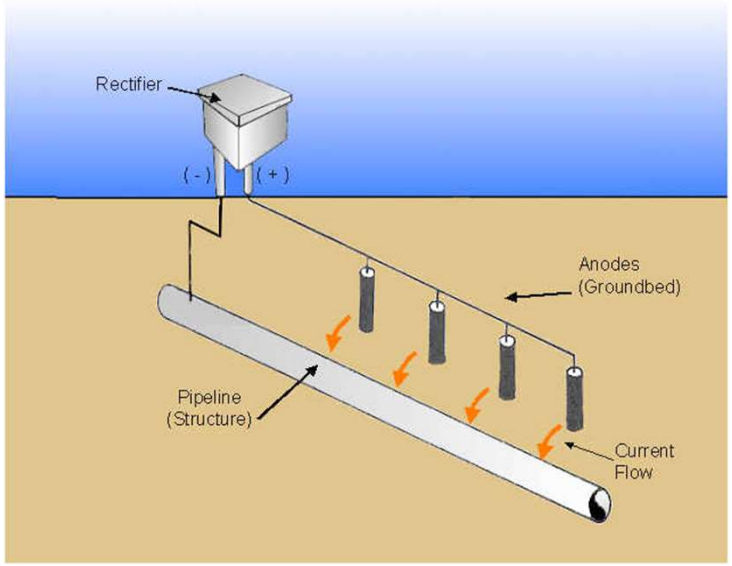
Eg Fuel storage tank or pipes underground




NEW ROD
OLD ROD

- Another method is by protecting the steel/iron as the cathode in an electrolytic cell.
- An applied DC voltage protects the metal by making it negative, preventing oxidation. The positive is connected to a scrap metal object and can be replaced when consumed.
- Eg Steel Jetty in ocean



# On-going work

1. Please read and complete the essential chemistry questions on corrosion – if you have an old textbook you will find a scanned copy of this section on OneNote

2. Practice exam question – this is from last years WACE exam