Chemistry Investigatory Project

Effect of Metal Coupling on the Rusting of Iron

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Class XII A
(2017-2018)

ACKNOWLEDGEMENT

It is with immense respect and gratitude, I express my thanks to all those who have inspired, motivated and guided me during the completion of the project work.

First and foremost, I am grateful to the Almighty for helping me to complete this project.

I express my sincere gratitude to the Principal, Mrs. Lalitha Suresh, Headmistress, Mrs. Usha Balachandran and the Supervisior,Mrs. Bharati Bakshi, for having provided me an excellent institution with well qualified staff.

With a deep sense of gratitude, I extend my sincere thanks to my Teacher, Mrs. Monika Sharma for her constant source of guidance and support . Also, I express my in debt thanks to the Teaching and Non-teaching Staff of Gems Our Own Indian School, especially to the Lab Attendant, Mr. Prakash Kumar and Mrs. Shiji Jaocb for all the encouragement given to me to complete this project.

Further, I express my gratitude to my beloved family and friends, who have continuously supported and encouraged me, without whom I would not have been able to complete this project.

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INTRODUCTION

❖ I. WHAT IS CORROSION ?

- Corrosion is a natural process whereby a metal is converted to a more chemically stable form like oxides, sulphides or hydroxides.
- It causes deterioration of a metal as a result of chemical reactions between the exposed material's surface and the surrounding environment.
- Both the type of metal and the environmental conditions, determine the form and rate of deterioration.

❖ II. EXAMPLES:

- Most metals corrode easily except the metals like gold, platinum, palladium etc. *(NOBLE METALS)*

  Some examples of Corrosion include:

1. Corrosion of Iron (RUST):

Formation of reddish brown {$Fe_2O_3.xH_2O$)
Hydrated ferric oxide

1. Corrosion of Silver :

Formation of black (H_2S) Hydrogen sulphide

3. Corrosion of Zinc :

Pitting in sculptures - Zinc corrosion

4. Corrosion of Copper :

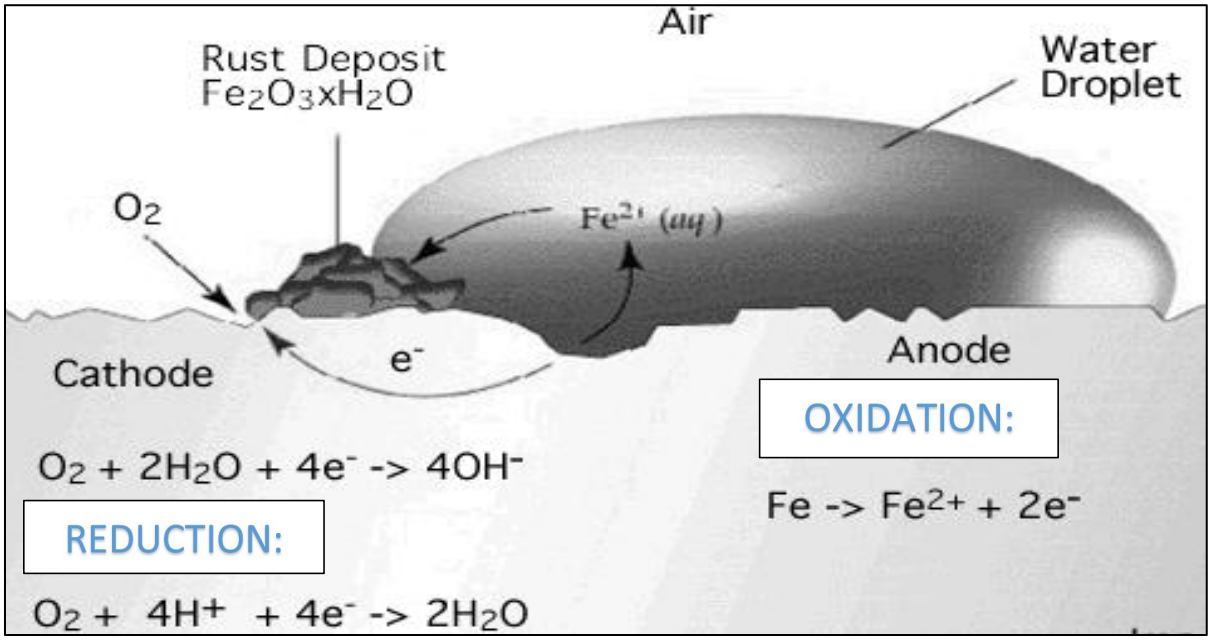
Formation of greenish-yellow substance

➢ Here , we shall focus on the corrosion of iron or it is also called RUSTING

❖ III. RUSTING:

- Though quite complex , rusting can be called an electrochemical reaction.
- Rusting takes place in the presence of moisture and oxygen. The iron is oxidised to oxygen and other oxides due to loss of electrons.
- At a particular spot of the iron object, oxidation takes place due to loss of electrons and the spot behaves like an anode.
- Electrons released at anodic spot move to another spot on the metal. These electrons reduce the oxygen in the presence of H^+. This spot behaves as a cathode with the reaction.

- Here, the hydrogen ions is believed to be available from carbonic acid H_2CO_3 (formed due to dissolution of CO_2 in water)



ATMOSPHERIC OXIDATION:

$$2Fe^{2+}(aq) + 2H_2O(l) + 1/2\ O_2\ (g) \longrightarrow Fe_2O_3(s) + 4H^{+}(aq)$$

Thus the ferrous ions are further oxidised by atmospheric oxygen to ferric ions which come out as rust in the form of hydrated ferric oxide as shown in the above reaction.

❖ IV. UNDESIRABLE EFFECTS :

- Corrosion affects the micro structure, mechanical properties and the physical appearance of the materials.
- Rusting and other types of deterioration drastically reduces the capacity of pipelines and equipment, resulting in:

1. Less output or inefficiency
2. Loss of equipment
3. Damage to equipment can cause accidents and lead to infections or loss of lives.
4. Depletion of natural resource (Metals)

- Every country spends billions every year on account of corrosion. Hence, various measures are used to combat the corrosion damage to critical structures and equipment.

❖ V. PREVENTIVE MEASURES :

Corrosion of metals can be prevented if the contact between metal and air or metal and moisture is cut off. This is done in a number of ways. Some of the methods are given below:

- **Protection by Coating:** Corrosion can be prevented if the metal is coated with something which does not allow moisture and oxygen to react with it. For e.g: Coating of metals with paint, oil, grease or varnish prevents the corrosion of metals.

- **Protection by metals:** Iron articles are protected from rusting by covering them with a thin layer of a more electropositive metal. This is called sacrificial protection or metal coupling.

1. If the metal used is zinc in this process it is called Galvanization. The zinc, participates in the Anodic

region's reaction and prevents iron from being oxidised. So, iron will not rust.

2. **Tinning:** It is the process of giving a coating of tin, i.e., molten tin. Cooking vessels, made of copper and brass get a greenish coating due to corrosion. This greenish coating is poisonous. Therefore they are given a coating of tin to prevent corrosion.

3. **Electroplating:** In this method of a metal is covered with another metal using electrolysis. Silver-plated spoons, gold-plated jewellery, etc, are electroplated.

4. **Anodizing:** In this method metals like copper and aluminium are electrically coated with a thin strong film of their oxides. This film protects the metals from corrosion.

5. **Alloying:** Corrosion can be also prevented by alloying some metals with other metals. The resultant metals called alloys do not corrode easily, e.g. Stainless steel.

EXPERIMENT

❖ 1. AIM :

The aim of the project is to investigate the effect of metal coupling on the rusting of iron.

❖ 2. THEORY :

Metal coupling affects the rusting of iron . If the nail is coupled with a more electropositive metal like zinc, magnesium or aluminium, rusting can be prevented. But on the other hand, if iron is coupled with a less electropositive metal like copper, rusting is facilitated or increases.

Fe-Zn couple Zn ⟶ Zn + 2e (Zn > Fe in terms of electropositivity)

Fe-Cu couple Fe ⟶ Fe + 2e

Cu ⟶ Cu + 2e (DOES NOT OCCUR since Cu < Fe in terms of electropositivity)

❖ 3. REQUIREMENTS :

(i) Apparatus:

- Sand paper
- 4 iron nails
- Magnesium strip, Zinc strip, Copper wire,
- Two Petri dishes
- 400 ml beaker
- Glass rod

(ii) Chemicals:

- Agar-agar (2.5 g)
- 0.1 M potassium ferricyanide solution
- 0.1 % phenolphthalein solution
- Carbon tetrachloride solution ($CCl_{4)}$
- Distilled water

❖ 4. PROCEDURE :

1) Clean the surface of iron nails with the help of sand paper. Wash them with CCl_4 many times to remove any greasy substance sticking to them and dry them.

2) Keep the first nail as such and wind a zinc strip around the second nail, a clean copper wire around the third & a magnesium ribbon around the fourth nail.

3) **Preparation of Agar-Agar solution**:

- Boil 250 ml distilled water in 400ml beaker. Remove the burner and add 2.5 g of powdered agar-agar slowly with constant stirring with a glass rod till it is completely dispersed in solution. Add to it 10-12 drops of 0.1M potassium ferricyanide solution followed by a few drops of 0.1 % phenolphthalein solution. Stir well and allow it to cool.

4) In Petri dish No.1, place the **bare nail** and the one wound with **copper wire** such that the do not touch each

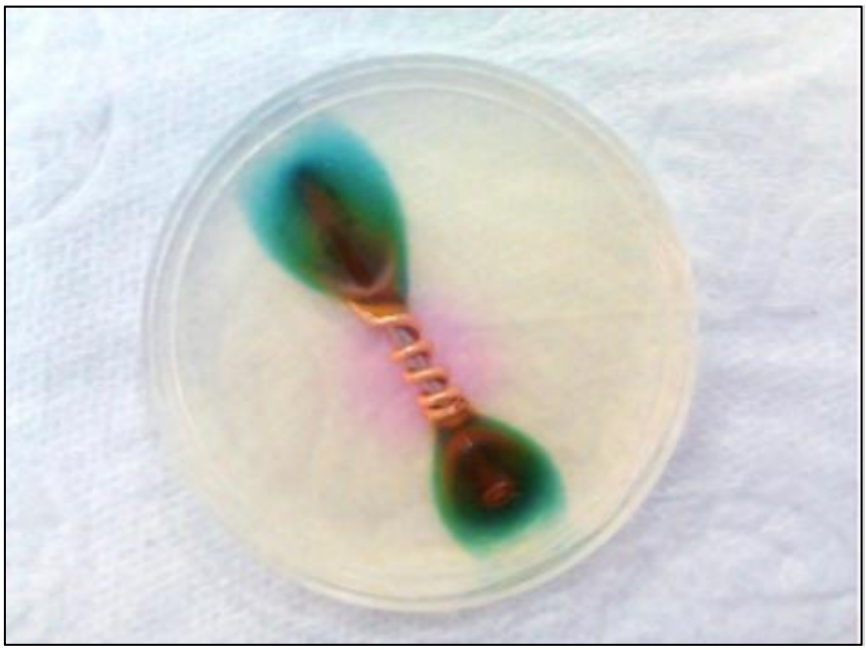
other. In a similar manner, place the remaining two nails wound with **zinc** and **magnesium** in Petri dish No.2.

5) Pour the lukewarm agar-agar solution in both the Petri dishes so as to cover the nails upto a a depth of 0.5cm or so.

6) Cover the dishes and allow them to stand for a few hours (preferably overnight). The jelly will settle after some time.Observe the patches around the nails and record it.

❖ 5. OBSERVATIONS :

NAIL NO	METAL/ COUPLE	COLOUR OF PATCH	RUSTING OCCURED OR NOT?
1.	Fe	Blue-pink	YES
2.	Fe-Cu	Blue-pink	YES
3.	Fe-Zn	Colourless	NO
4.	Fe-Mg	Colourless	NO



❖ 6. RESULT :

The liquids set to a gel on cooling. Two types of patches are observed around the **rusted nail, one is blue and the other pink.** (Fe, Fe-Cu couple)

Blue patch is due to the reaction between the ferrous ions formed with the potassium ferricyanide to form blue precipitate of Potassium ferro-ferri cyanide.

{ $KFe[Fe(CN)_6]$ }

Pink patch is due to the formation of hydroxyl ions { OH^- } which turns colourless phenolphthalein to pink.

There is no coloured patch around the nail which does not rust. (Fe-Zn,Fe-Mg couple)

❖ 7. CONCLUSION :

Coupling of iron with more electropositive element like zinc and magnesium resists corrosion and rusting of iron.

But coupling of iron with less electropositive element like copper leads to increased corrosion of iron.

❖ 8. PRECAUTIONS :

1. Only bright and shining nails to be used
2. Nails placed in same Petri dish must not touch each other.

BIBLIOGRAPHY

For the project I have taken help from the following resources :

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