45 CORROSION
EXPERIMENT

PURPOSE

To investigate various physical and chemical conditions that may affect the corrosion of iron.

BACKGROUND

Each year, the corrosion of metals does untold damage to cars, homes, and factories. *Corrosion* is a complex reduction–oxidation (redox) reaction in which metals are changed to their oxides or other compounds. In a corrosion reaction, electrons flow from the anode to the cathode. The anode and the cathode may be two different parts of the metal being corroded, or the cathode may be a different object that is in electrical contact with the metal being corroded.

In this experiment you will study a variety of factors involved in the corrosion of iron.

MATERIALS (PER PAIR)

safety goggles
6 small test tubes
1 test-tube rack
1 250-mL beaker
2 petri dishes, with lids
1 ring stand
1 ring support
1 wire gauze
1 gas burner
1 glass stirring rod
pliers
1 dropper pipet
9 uncoated iron nails, Fe
thin zinc strip, Zn (0.25 mm thick, 0.2-cm × 5.0-cm)
copper wire, Cu (1.5 mm diameter, 10 cm long)
steel wool
agar, powdered
litmus paper or Hydrion paper
phenolphthalein solution
0.1*M* iron(II) sulfate, $FeSO_4$ [T]
0.1*M* potassium ferricyanide, $K_3Fe(CN)_6$ [T]
distilled water

Solution Set 1

0.1*M* sodium hydroxide, NaOH [I]
0.1*M* sodium dichromate, $Na_2Cr_2O_7$ [T] [I]
0.1*M* sodium chloride, NaCl
0.1*M* hydrochloric acid, HCl [I]

Solution Set 2

0.1*M* potassium hydroxide, KOH [C]
0.1*M* sodium carbonate, Na_2CO_3
0.1*M* potassium nitrate, KNO_3 [I]
0.1*M* nitric acid, HNO_3 [C]

Solution Set 3

0.1*M* sodium phosphate, $NaPO_4$ [I]
0.1*M* sodium oxalate, $Na_2C_2O_4$ [T]
0.1*M* sodium thiocyanate, NaSCN [T]
0.1*M* sulfuric acid, H_2SO_4 [C]

SAFETY FIRST!

In this lab, observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the procedure, refer to the list below for its meaning.


Caution: Wear your safety goggles. (All steps.)


Caution: Nitric, hydrochloric, and sulfuric acids are irritating and corrosive. (Step 2.)


Caution: Sodium oxalate and sodium dichromate are toxic. Avoid contact with these chemicals. (Step 2.) Never pick up a dropper bottle by its cap. (All steps.)


Caution: Potassium ferricyanide can react with acids and chromates to produce toxic fumes. (Steps 6, 11, and 12.) Read all labels carefully and mix chemicals only according to directions. (All steps.)


Caution: Exercise care when working with hot agar. It can cause severe burns to the skin. (Step 5.)


Note: Return or dispose of all materials according to the instructions of your teacher. (Step 14.)

PROCEDURE

As you perform the experiment, record your observations in Data Table 1.

Part A. Reaction of Iron with Aqueous Solutions (Day 1)


1. Clean five iron nails with steel wool. Place each nail in a separate small test tube.



2. Your teacher will assign you one of the three sets of chemicals listed in the Materials section. Fill each of four test tubes with a different solution from the set until each nail is just covered. Fill the fifth tube with distilled water. Put the tubes in a test-tube rack.
3. Use litmus or Hydrion paper to determine whether each solution is acidic, basic, or neutral. Record the results in Data Table 1.
4. Allow the test tubes to stand overnight. You will study them tomorrow, when you begin with Step 10.

Part B. Effects of Stress, and Protection by Other Metals (Day 1)

5. Heat 100 mL of distilled water to boiling in a 250-mL beaker. Remove the gas burner. **CAUTION:** *Hot agar causes severe burns to the skin.* Add, while stirring, 1 g of powdered agar. Replace the burner; heat and stir the mixture until the agar forms a suspension. Be careful not to burn the agar. Stop heating and turn off the gas burner.

6. Add 5 drops of 0.1*M* potassium ferricyanide and 3 drops of phenolphthalein to the agar suspension. Stir to mix thoroughly. Allow the agar to cool, but not set, while you proceed to the next step.

7. Clean four irons nails with steel wool. Place one nail in a Petri dish. Use pliers to bend a second nail into a right angle. Place the bent nail beside, but not touching, the straight nail (see Figure 45.1). Tightly wrap a 10-cm piece of copper wire around a third nail. Wrap the fourth nail tightly with a thin strip of zinc metal. Place these two metal-wrapped nails in a second Petri dish. Be sure that the nails do not touch (see Figure 45.1).

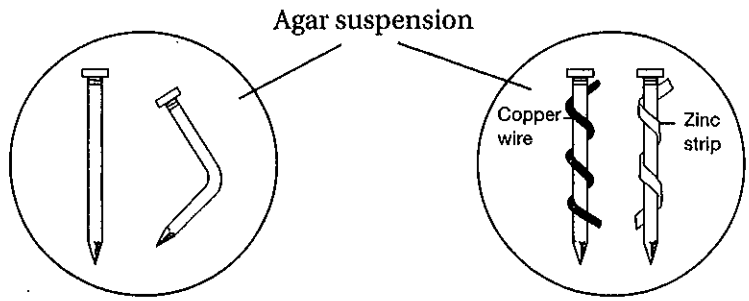

Figure 45.1

8. Pour the warm agar suspension into the Petri dishes. The nails and attached pieces of metal should be covered by agar to a depth of at least 2 mm.

9. View the dishes against a white background and make observations at the end of the class period. Cover the dishes and keep them undisturbed overnight. You will observe them again tomorrow.

Part C (Day 2)

10. Observe, against a white background, the test tubes that have stood overnight. In Data Table 1, record any evidence of reaction.

11. Test for the presence of ferrous ions, Fe^{2+}. In a separate small test tube, add one drop of 0.1*M* potassium ferricyanide to 1 mL of 0.1*M* iron(II) sulfate. Record your observations.

12. Now, test each of the five test tubes containing the nails for the presence of ferrous ions by adding 1 or 2 drops of 0.1*M* potassium ferricyanide. Record your observations. The presence of ferrous ions in the test tubes is evidence that corrosion has occurred.

13. Observe the dishes against a white background. Record your observations by sketching the dishes in Figure 45.2 on page 290. Show the location and color of any reaction products.

14. Follow your teacher's instructions for proper disposal of the materials.

Name _____ Class _____ Date _____

OBSERVATIONS

DATA TABLE 1: OBSERVATIONS

Test Solution	pH	Initial Observations	Observations after 24 hours	*Test with $Fe(CN)_6^{3-}$
Set 1 NaOH				
$Na_2Cr_2O_7$				
NaCl				
HCl				
Set 2 KOH				
Na_2CO_3				
KNO_3				
HNO_3				
Set 3 Na_3PO_4				
$Na_2C_2O_4$				
NaSCN				
H_2SO_4				
Controls H_2O				
$FeSO_4$	reference test for presence of Fe^{2+} ions			

*Positive: production of blue color indicates the presence of Fe^{2+} ions in solution. Negative: no blue color

Name _____ Class _____ Date _____

Figure 45.2

ANALYSES AND CONCLUSIONS

1. Obtain class data for the two sets of chemicals that you did not use in Part A. Enter this data in Data Table 1.
2. List the chemicals used in Part A for which there was no evidence of corrosion.

3. List the chemicals used in Part A for which there was evidence of corrosion.

Name _____ Class _____ Date _____

4. Did either copper or zinc appear to protect the iron nail against corrosion? Explain.

5. Explain how the colors that developed in the petri dishes identify the anode and cathode for each reaction.

6. What were the usual sites where corrosion took place for the nails embedded in the agar?

7. Examine the data for Part A. Are there any ions that seem to inhibit corrosion or to promote it? Try to explain these effects.

8. Explain the results obtained in distilled water.

Name _____ Class _____ Date _____

9. Consider your answer to problem 6. What effect does bending seem to have on the tendency of iron to corrode?

10. Explain the effects caused by wrapping the nails with zinc or copper. Discuss the relative ease of oxidation of iron, zinc, and copper in your answer.

11. Is it correct to say that corrosion did not take place in the nail wrapped with zinc? Explain.

GOING FURTHER

Develop a Hypothesis

Based on the results of this lab, propose a hypothesis about other ways of preventing or retarding the corrosion of iron based materials.