Corrosion/Conservation/Preservation

INTRODUCTION

The Corrosion lesson will explore reasons why metal corrodes and ways to treat and preserve artifacts.

OBJECTIVES

By the end of this lesson, the student will be able to do the following:

- Summarize the causes of metal corrosion in regards to electrochemical processes.
- Describe the affects salt water has on submerged metal.
- Identify and describe metal corrosion on iron.
- Compare and contrast the effects of corrosion on various types of metals.
- Summarize the reasons for metal preservation.
- List the preservation treatments for iron:

    1. Electrochemical cleaning
    2. Galvanic cleaning
    3. Electrolytic reduction
    4. Alkaline Sulfite
    5. Chemical cleaning
    6. Annealing

- Differentiate between cast iron and wrought iron and the methods in which they corrode.
- Identify occupations associated with archeological preservation, conservation, and water chemistry.

Corrosion

1. Explanation of corrosion on submerged metal.
   a) Corrosion is a process of wearing away or destruction of metals by a chemical agent or process.
   b) An electrochemical reaction occurs when one metal contains positively charged ions and another metal contains negatively charged ions. When an electrical conductor is connected between them, the current will flow as in the discharge of a battery. The elements involved in an electrochemical reaction are characterized by the number of electrons each has. An ion is an atom having a negative or positive charge as a result of having lost or gained one or more electrons. For example when sodium reacts with chlorine, sodium donates one electron and gains an oxidation state of +1. Chlorine accepts the electron and gains an oxidation state of -1. The sign of the oxidation state (positive/negative) actually corresponds to the value of each ion's electronic charge.

2. Effects seawater has on submerged metals
   a) The corrosion of iron in seawater proceeds in somewhat the same manner but is greatly accelerated because water becomes more corrosive as the salt content increases. For example, iron corrodes ten times faster in seawater than in air.
   b) An electrolyte is a compound that ionizes or splits into positive ions and negative ions (such as NaCl in seawater = Na+ and Cl-) and forms a "bridge" to speed up the flow of current and increase the rate of corrosion. The salt in seawater is the greatest single cause of corrosion.
   c) The direction of the flow of current will go toward the negatively charged metal until the positively charged metal is destroyed.
   d) Another corrosion factor is the relationship between dissimilar metals.

3. Appearance of corrosion
   a) The appearance of corrosion will vary with each metal involved, for this lesson we will concentrate on iron and steel.
   b) Iron and steel corrosion are possibly the most easily recognized of all forms of metallic deterioration.

c) When iron and steel corrode, a dark iron oxide coating usually forms first followed by the appearance of corrosion is a reddish-colored iron rust.

3. Corrosion Experiments
   a) Set up four different stations to perform the 6 following experiments.
   b) Have students perform the experiments.
   c) After all stations are finished, gather the students and complete the Conservation/Preservation lesson.

Root Killer Experiment

Equipment:
root killer (copper sulfate pentahydrate)
glass
water
iron nail
sandpaper

Method:
Go to a hardware store and get root killer. Look at the package, it should be copper sulfate pentahydrate. When you open it up, it should be blue crystals. This is good stuff to work with, but be careful, it is poisonous so be sure to wash your hands after touching it. Drop some in a glass and dissolve in water. Then get an iron nail and sandpaper it a bit to make it shiny. Drop it in and wait a few hours. It will become copper-plated. (Has to do with the relative activity of metals)

Root Killer in Excess

Equipment:
excess of root killer (copper sulfate pentahydrate)
water
glass
old spoon
copper wire
DC power supply of at least 3 volts
connecting wire

Method:
Dissolve more root killer in the water- this time to excess (have crystals sitting on the bottom of the glass). Connect an old spoon to a wire and connect that wire to the negative pole of a DC power supply. Connect some copper wire to the positive pole of the DC power supply. The other end of that copper wire should be stripped clean and dropped in the water. Don't let the two touch while in the water. After a while, the copper wire in the water will start to shrink in size but the spoon will get a copper coating (copper plated). The DC power supply can be batteries but use at least 3 volts.

Slow Burn

A slow burn - get plain steel wool (non-detergent) and regular Clorox (again - non-detergent). Place the steel wool in a large glass bowl. Pour the Clorox over it, covering it. Let this mixture sit overnight. Come back tomorrow and most of the steel wool is gone and you now have rust. (P.S. this will make the Clorox quite warm - let it sit in a sink overnight in case it breaks - don't squeeze the steel wool before you use it. Just put in as-is - if you squeeze it or stretch it, the reaction will go faster and become hotter). Rinse thoroughly with water when done.

3 Iron Nails Experiment

Equipment:

3 iron nails
3 glasses (small wine or sherry glasses are ideal)
cooled water (boil a kettle of water then allow the water to cool until it is just warm)
Olive or sunflower oil
Wire wool / fine sandpaper

Method:
Clean each of the nails with steel wool or fine sandpaper. Fill two of the glasses with cooled water, enough to cover the nail, but leaving a fingers depth unfilled. Leave the third glass dry. Add a nail to each of the glasses, and then pour a layer of oil over the water in one of the glasses. The oil will float to the top of the water and form a separate layer which should be about as thick as a pencil.

Carefully place the experiment somewhere that it can remain undisturbed and easily observed for 24 hours.

Observe the mixture after a few hours; take notes of what you can see. Has any corrosion taken place? If you see corrosion, what is the color of the corrosion that you see? Rate the level of corrosion of each of the items from 0 to 5 (0 being no corrosion, 5 being very corroded). Repeat this observation after 24 hours.

Aluminum Foil Experiment

Method:

Take two glasses and half fill them with water. Mix two spoonfuls of salt into to one glass, and leave the other with fresh water. Put one piece of aluminum foil into each of the glasses and allow it to sink (**make sure that you do not contaminate the non-salty aluminum foil or water with salty fingers!**). Observe the glasses after a few hours; take notes of what you can see. Observe after 18-24 hours; take notes of what you see. You can take the aluminum foil out of the water to take a closer look.

If you see corrosion, what is the color is the corrosion that you see? Rate the level of corrosion of Observe the mixture after a few hours; take notes of what you can see.

Aluminum, Copper, Solder Experiment

Equipment:

5 iron nails
1 piece of aluminum kitchen foil
2 lengths of stripped copper electrical wire (4" 12cm in length)
2 lengths of silver solder (as used in circuitry or plumbing)
Small piece of wire wool or fine sandpaper
Shallow glass/ceramic dish (I used a Pyrex dish) large enough to contain all the nails
Salt

Method:

Clean each of the nails with wire wool or fine sandpaper. Gently clean the silver solder and copper in the same way. Wrap the aluminum foil around the head of one nail, the copper wire around the head of another, and the silver solder around a third (**ensure that the wrapping is tight and that there is a good bond between the two metals**).

The fourth nail is not joined to anything. Then wrap a piece of copper wire around the other length of silver solder.
Fill the dish with warm water, add a teaspoon of salt and stir until it is dissolved. Carefully place the bowl somewhere that it can remain undisturbed for 24 hours, and so that you can easily observe it without having to move it.

Carefully add each of the metal items you prepared to the water - **make sure that they are not touching each other**.

Observe after 12-15 hours; take notes of what you see. Which items have corroded? Have some corroded faster than others? If you see corrosion, what is the color of the corrosion that you see? Rate the level of corrosion of each of the nails from 0 to 5 (0 being no corrosion, 5 being very corroded).

Nails on Battery Experiment

Equipment:
1 battery (1.5 volt AA) - **do not use a higher voltage** for this experiment
2 iron nails
1 elastic band about the same length as the battery
1 small piece of wire wool or fine sandpaper
1 shallow (1" or 3cm) glass dish - a dish lid or a glass ashtray would be ideal

Method:
Clean the two nails thoroughly with wire wool or fine sandpaper. Fill the glass dish with water. For this experiment you should **NOT** add salt - as it will affect the type of reaction that occurs.
Wrap the elastic band around the nail lengthways, so that it covers the terminals. Gently pull the band away from each terminal, and place a nail under it, allowing the band to hold the nail firmly in place against the terminal. Tie a knot in the band at the back to make a smaller loop.

from 0 to 5 (0 being no corrosion, 5 being very corroded). Make absolutely sure that the band is tight enough to hold the nails in place, and that the shaft of each nail is in contact with the battery terminal. Place the tips of the nails into the water in the dish, leaning the battery against the side. Use the knot tied in the elastic band as an anchor on the lip of the dish. The battery should **not** be in the water, only the tips of the nails. Secure the battery using adhesive tape if necessary to make sure that it does not fall into the water. Your completed experiment should look like the right hand picture above.

Observe the experiment immediately. Can you see any reaction? Look very closely at both nails for a minute or two. Take notes of what you can see. Observe the mixture after 5 or 6 hours. Has any corrosion occurred? Which items have corroded? Rate the level of corrosion of each of the items from 0 to 5 (0 being no corrosion, 5 being very corroded). Observe for a final time after 12-15 hours or longer

Artifact Preservation

1. Overview
    a) Artifact preservation is one of the most important concerns to consider when planning an action that will result in artifact recovery.
    b) It is the responsibility of the person recovering the objects to ensure that they are properly conserved.
    c) Without conservation efforts, most artifacts and important historic data would be lost.
    d) Artifacts recovered from salt water are often well preserved but easily crumbled.
    e) Artifacts not properly conserved will deteriorate at a rapid pace and become useless for further studies.
    f) Organic material like leather, wood, textile, rope, etc. will be destroyed in a matter of hours if permitted to dry without treatment.
    g) Iron can last for a longer period of time without treatment but again will be destroyed at a higher rate of deterioration.
2. Iron Conservation
    a) Iron corrodes ten times faster in seawater than in air.
    b) On ships constructed prior to 1900, all ferrous metals were either cast or wrought iron.
    c) Cast iron artifacts (i.e. cannons, cannon balls) corrode in the form of graphite flakes.
    d) Cast iron corrodes from the outer layer inward.
    e) Wrought iron will corrode along lines of slag inclusions that were formed when the iron was folded, hammered, and forged into place.

f) Cast and wrought iron require the same treatment but the main aim is to rid the metal from salt to prevent the metal from corroding further.

g) The conservation of iron objects comes under five main categories:

1. Electrochemical, galvanic cleaning and electrolytic reduction.
2. Alkaline Sulfite
3. Chemical cleaning
4. Annealing – to make metals less brittle by heating
5. Water diffusion in alkaline solution

3. When the preservation lesson is finished (or after 1 hour), return to each station and write down observations of the experiments and explain what is happening.

Some experiments will need to be left overnight to see the full effects of the experiments.