

Microscale Electroplating Lab

Industrial Chemistry



Introduction

Investigate how and where the electroplating occurs using metal strips, graphite electrodes and paper clips.

Concepts

- Electrolysis/electroplating
- Oxidation–reduction

Materials

- | | |
|---|-------------------------|
| Copper(II) sulfate solution, 0.5 M, 30 mL | Paper clips, small |
| Copper, strip | Pencil lead, 0.9-mm |
| Copper wire, 18–20, gauge, 6 cm | Petri dish |
| Zinc sulfate solution, 1 M, 20 mL | Pipets, disposable, 2 |
| Zinc, strip | Pliers, needle-nose |
| Battery clip | Reaction plate, 24-well |
| Battery, 9-V | Steel wool |
| Paper clips, large | Tape, transparent |

Safety Precautions

Copper sulfate solution is slightly toxic by ingestion. Zinc sulfate solution may cause skin and eye irritation. Avoid skin contact with all chemicals. Do not operate electrical circuits with wet hands or in wet areas. Be sure the area is dry before completing a circuit. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Assemble the graphite electrode assembly.
 - a. Place a 3-cm piece of transparent tape sticky-side up on the table.
 - b. Break a mechanical pencil lead into two equal halves. *Note:* Mechanical pencil leads are fragile. Place each piece on the tape as shown in Figure 1.
 - c. Place a small paper clip on each rod, so that the rod fits snugly between the paper clip outer and inner loops (A) as shown in Figure 2.
 - d. Place a second piece of tape, sticky-side down on top to hold the assembly together.
 - e. Trim away any excess tape from the edges.
 - f. Connect the battery clip leads to the exposed loops of the paper clips.
2. Construct a copper wire assembly.
 - a. Bend a piece of 18–20 gauge copper wire into an S-shape.
 - b. Use pliers to wrap one end around the end of a small paper clip (see Figure 3).
 - c. Wrap the juncture with a small piece of tape.

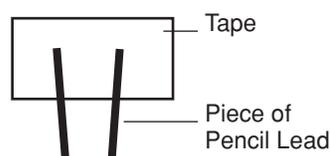


Figure 1.

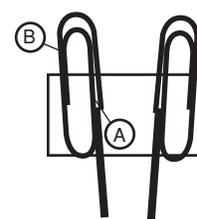


Figure 2.

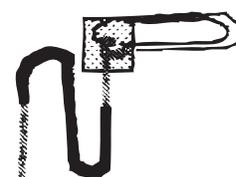


Figure 3.

Procedure

Part 1. Electroplating Copper and Zinc

1. Fill the lid of a Petri dish approximately 3/4 full with 0.5 M copper(II) sulfate solution.
2. Fill the bottom of a Petri dish approximately 3/4 full with 1 M zinc sulfate solution.
3. Dip the zinc strip into the 0.5 M copper(II) sulfate solution. Record any observations.
4. Dip the copper strip into the 1 M zinc sulfate solution. Record any observations.

Part 2. Electroplating Graphite Electrodes

1. Use a pipet to fill the corner well of a 24-well plate approximately 3/4 full with 0.5 M copper(II) sulfate solution.
2. Attach the graphite electrode assembly to the 9-V battery. Make sure the graphite electrodes don't touch each other.
3. Place both graphite electrodes in the 0.5 M copper(II) sulfate solution for several seconds (see Figure 4). *Note:* Do not touch the two graphite electrodes together.
4. Record any observations, making sure to note which electrode (positive or negative) causes which change.

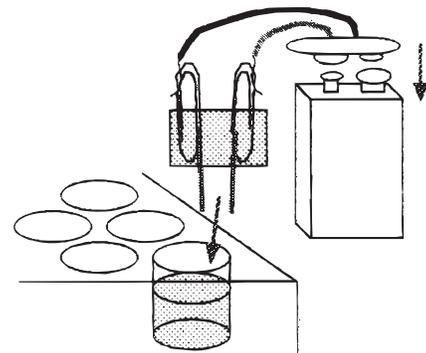


Figure 4.

Part 3. Electroplating a Paper Clip

1. Use a pipet to fill the corner well of a 24-well plate approximately 3/4 full with 0.5 M copper(II) sulfate solution.
2. Clean a large paper clip with a piece of steel wool. Clip the cleaned large paper clip to the black lead of the battery clip
3. Clip the copper wire assembly to the red lead of the battery clip.
4. Place the free end of the copper wire assembly into the 0.5 M copper(II) sulfate solution (see Figure 5).
5. Squeeze the S-curve together a bit so that it clips securely onto the side of the well as shown in Figure 3.
6. Dip the free end of the large paper clip into the copper(II) sulfate solution for several seconds. *Note:* Do not touch the paper clip and the copper wire together.
7. Record any observations, making sure to note which electrode causes the change. Do the same reactions happen as happened with the graphite electrodes?
8. Now switch the leads: attach the red lead to the large paper clip and the black lead to the copper wire assembly and observe.

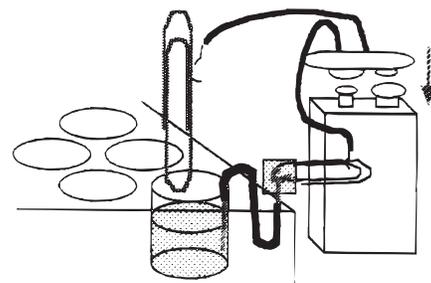


Figure 5.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Excess copper sulfate solution and zinc sulfate solution may be disposed of down the drain with an excess of water according to Flinn Suggested Disposal Method #26b.

Tips

- Use 0.9-mm pencil leads as the graphite leads instead of thinner more fragile leads.
- The graphite leads can be cleaned with a paper towel (or lightly with steel wool if necessary) after each use to remove the copper plating. Carefully cleaning the electrodes takes less time than rebuilding them.
- A similar kit is available from Flinn Scientific as a student laboratory kit. See Electroplating with Copper—Student Laboratory Kit (Catalog No. AP6132) in your current *Flinn Scientific Catalog/Reference Manual*.

Discussion

Some particles have a stronger tendency to attract electrons than others. For example, the Cu^{2+} ion is much better at attracting electrons than is the Zn^{2+} ion. Thus, if a Zn^{2+} already has the electrons (and is thus the Zn atom), a Cu^{2+} can easily come along and steal them away, making itself into an atom and leaving the Zn as an ion: $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$. Thus, when a piece of zinc (made up of neutral Zn atoms) is placed in a solution of some copper salt (containing Cu^{2+} ions), then the reaction occurs spontaneously. But, if the reverse is tried and a piece of copper (made up of neutral copper atoms) is placed in a solution containing zinc ions, nothing happens: $\text{Zn}^{2+} + \text{Cu} \rightarrow \text{NR}$. Therefore, this reaction is said to be nonspontaneous.

Electrochemistry is the study of the interconversion of electrical and chemical energy. Two types of cell processes can result in the interconversion of these two energy sources—voltaic cells and electrolytic cells. *Voltaic cells* use a spontaneous chemical reaction to generate electrical energy. *Electrolytic cells* use electrical energy (e.g., from a battery) to make a nonspontaneous chemical reaction take place. A nonspontaneous process requires energy from an external source in order to drive the reaction to occur. The electroplating reaction performed in this lab activity is an example of an electrolytic nonspontaneous process.

The chemical reactions that take place in electrochemical cells are *redox* reactions. Reduction occurs at the cathode (negative [–] electrode) and oxidation occurs at the anode (positive [+] electrode). Within an electrochemical cell, positive ions (cations) move toward the cathode and negative ions (anions) move toward the anode.

In the electrolytic cells that are used in this lab activity, the nonspontaneous oxidation–reduction reactions occurring at the electrodes are the result of the transfer of electrons by the power supply. The power supply acts as an electron pump, pushing electrons into the cathode and removing them from the anode. Electrical neutrality, however, must be maintained; therefore, some process must consume electrons at the cathode and generate them at the anode.

The half-reaction occurring at the anode (the copper electrode) is the oxidation of copper to Cu^{2+} . When copper is oxidized to copper(II) ions, two electrons are produced according to Equation 1.



The half-reaction occurring at the cathode (the metal key or object) is the reduction of copper(II) ions to copper. When copper(II) ions are reduced to copper metal, two electrons are consumed according to Equation 2.



Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Evidence, models, and explanation

Constancy, change, and measurement

Content Standards: Grades 5–8

Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Microscale Electroplating Lab* activity, presented by Penney Sconzo, is available in *Industrial Chemistry*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Microscale Electroplating Lab* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0246	Copper(II) Sulfate Solution, 1 M, 500 mL
C0182	Copper, Strips, Pkg. of 6
C0148	Copper Wire, 18 Gauge, 4 oz.
Z0031	Zinc Sulfate Solution, 1 M, 500 mL
Z0024	Zinc, Strips, Pkg. of 10
AP8954	Battery Clips with Alligator Clip Leads, 2
AP1430	Battery, 9-V
AP1817	Pencil Leads
AP1447	Reaction Plate, 24-well
GP3019	Petri Dish

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.