Tin Man Electrolysis

Electrolysis Reactions

FLINN SCIENTIFIC CHEM FAX!

Introduction

What happens in an electrolytic cell if one of the ions in the electrolyte may be both oxidized and reduced? Electrolysis of tin(II) chloride provides a stunning example. Grow a beautiful “tin-man” crystal tree by running an electric current through a solution of tin(II) chloride. Students will enjoy watching this “electric” oxidation–reduction demonstration as tin crystals are produced and then redissolved when the direction of the current is reversed.

Concepts

- Electrolysis
- Anode
- Cathode
- Oxidation–reduction

Background

Electrolysis is the process of using an electric current to decompose compounds. An electrolytic cell requires several components including a power source, anode and cathode, and an electrolytic conducting solution. Oxidation occurs at the anode and reduction occurs at the cathode. Typically in an electrolytic cell, the positive electrode is the anode and the negative electrode is the cathode. In this demonstration, an electrical current is passed through a solution of tin(II) chloride.

Materials

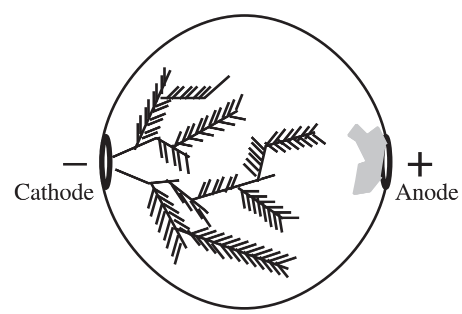
Copper or steel wire, 1–2 cm (optional)
Tin(II) chloride, $SnCl_2$, 5 g
Water, distilled or deionized, 100 mL
Battery, 9-V
Battery cap with alligator clip leads
Beaker 250-mL
Filter paper
Funnel
Overhead projector
Paper clips, small, 2
Petri dish
Ring clamp
Support stand

Safety Precautions

Tin(II) chloride is moderately toxic and a skin irritant. Avoid contact of all chemicals with eyes and skin. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Attach two papers clips to opposite sides of a clean glass Petri dish. Be sure the long ends of the paper clips are on the inside of the dish, nearly touching the bottom.
2. Dissolve 5 g of tin(II) chloride in 100 mL of deionized water in a 250-mL beaker.
3. Filter the tin(II) chloride solution and allow the liquid to drip into the Petri dish.
4. Collect enough liquid to just cover the bottom of the Petri dish.
5. Place the Petri dish on an overhead projector.
6. Attach the alligator clips from the 9-V battery cap to each paper clip.



7. Hook the battery cap to the 9-V battery and observe the changes at the anode and the cathode. *A milky white precipitate of tin(IV) chloride appears at the anode and metallic tin(0) crystals form at the cathode.*
8. Allow the current to run for approximately one minute to see the continued growth. The tin(0) crystals form feather-

like projections and grow across the dish.

9. Remove the alligator clip leads from the paper clips and switch the polarity of the electrodes by changing which paper clip the leads are attached to. The previous cathode will now be the anode and vice versa.
10. The crystal formation will reverse—tin crystals will grow at the “new” cathode and the existing crystals at the “new” anode will dissolve back into solution.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Leftover tin(II) chloride solution may be neutralized and treated according to Flinn Suggested Disposal Method #24b. All solid waste may be disposed of in the trash according to Flinn Suggested Disposal Method #26a.

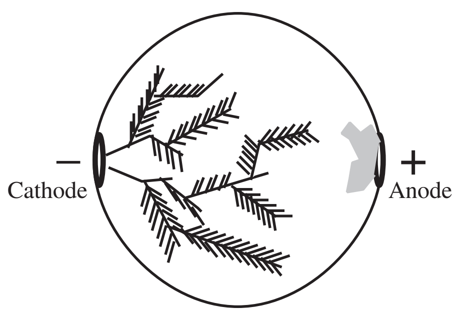
Tips

- The paper clips may turn black in the tin(II) chloride solution due to a reaction between the metal paper clip and the tin(II) ions. This does not affect the demonstration.
- Place a small piece of copper wire or a piece of a steel paper clip in the center of the Petri dish so that the ends are pointing at both of the alligator clips. When the electric current starts, tin metal will precipitate at the anode and crystals will grow at the cathode. The copper wire functions as a second electrode, therefore repeating the pattern.
- Place the Petri dish on top of a sheet of clear acetate transparency and place (+) and (–) signs on the sheet to show the polarity of the electrodes.

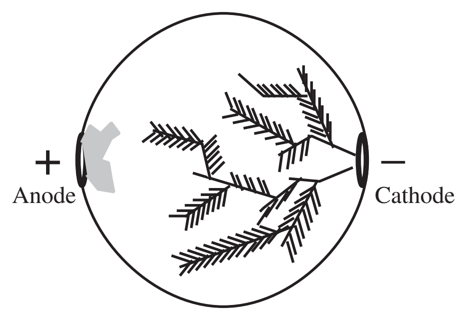
Answers to Demonstration Worksheet *(Student responses may vary.)*

The original conducting solution was tin(II) chloride ($SnCl_2$). The products of the electrolysis reaction are tin(0) and tin(IV) chloride.

1. Draw two sketches representing your observations during the first and second parts of this demonstration.



First Demonstration



Second Demonstration

Accept any reasonable student sketches.

2. How did the two products differ in appearance?

   One of the products [tin(0)] has a metallic, crystalline appearance, growing in feather-like projections outward from the negative electrode (cathode) and expanding across the Petri dish. The other product [tin(IV) chloride] is a milky white precipitate that remained localized near the electrode (anode). 3. Identify the products that were obtained at the anode and at the cathode, respectively.

   Anode – tin(IV) chloride

   Cathode – tin(0), tin metal

4. The electric current causes an oxidation–reduction reaction within the conducting solution.

   a. Which product results from reduction of tin(IV) ions?

Tin(0)

b. Which product results from oxidation of tin(IV) ions?

Tin(IV) chloride

5. What was observed when the "sign" or polarity of the electrodes was switched?

The products seemed to "reverse" their position. The original tin crystals and tin(IV) precipitate slowly redissolved and disappeared. Once the products from the first demonstration completely dissolved back into solution, new products formed at both electrodes. Since the placement of the anode and cathode was switched, the location of each product was also reversed.

Discussion

This demonstration utilizes an electric current to cause an oxidization-reduction reaction within a solution of tin(II) chloride. Tin(II) ions are oxidized to an insoluble precipitate of tin(IV) chloride ions at the anode and reduced to metallic tin [tin(0)] at the cathode.

Oxidation half-reduction (anode)	$Sn^{2+}(aq) \rightarrow Sn^{4+}(aq) + 2e^-$
	$Sn^{4+}(aq) + 4Cl(aq) \rightarrow SnCl_4(s)$
Reduction half-reaction (cathode)	$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$
Overall reaction (disproportionation)	$2Sn^{2+}(aq) + 4Cl^-(aq) \rightarrow SnCl_4(s) + Sn(s)$

The overall reaction is called a disproportionation reaction—a chemical reaction in which one reagent acts as both oxidizing and reducing agent. As a result, the reagent (Sn^{2+} ions) is converted into both a more oxidized and a more reduced product.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement
Evidence, models and explanation
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; interactions of energy and matter

References

This activity was adapted from Electrochemistry, *Flinn* ChemTopic™ Labs, Volume 17, Cesa, I., Ed.; Flinn Scientific: Batavia, IL, 2003.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Tin Man Electrolysis* activity, presented by Bob Becker, is available in *Electrolysis Reactions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Tin Man Electrolysis* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Reversible Tin Man—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP6867	Reversible Tin Man—Chemical Demonstration Kit
C0146	Copper wire, 16 gauge, 4 oz
S0227	Tin(II) chloride, 25 g
AP8954	Battery Clips with Alligator Clip Leads
AP1430	Battery, 9-V

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

Tin Man Electrolysis Demonstration Worksheet

The original conducting solution contains tin(II) chloride ($SnCl_2$). The products of the electrolysis reaction are tin(0) and tin(IV) chloride.

1. Draw two sketches representing your observations during the first and second parts of this demonstration.

First Demonstration Second Demonstration

2. How did the two products differ in appearance?

3. Identify the products that were obtained at the anode and at the cathode, respectively.

4. The electric current causes an oxidation–reduction reaction within the conducting solution.
   a. Which product results from reduction of tin(IV) ions?

   b. Which product results from oxidation of tin(IV) ions?

5. What was observed when the "sign" or polarity of the electrodes was switched?

