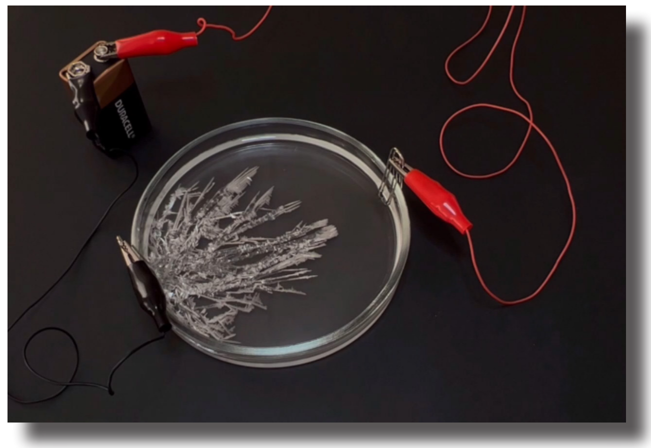
Stage demo

Tin Crystals

Demonstrate the growth of beautiful tin crystals using electrolysis

Question to investigate

How does electricity change a clear tin(II) chloride solution?



Chemistry covered

- ***Disproportionation reactions:*** $SnCl_2$ forms both $SnCl_4$ and tin metal
- ***Redox reactions:*** $SnCl_2$ loses electrons (is oxidized) to form $SnCl_4$ and gains electrons (is reduced) to form Sn
- ***Electrolysis:*** oxidation of $SnCl_2$ takes place at the anode and reduction of $SnCl_2$ takes place at the cathode

Special considerations

- Best done in a laboratory setting or venue in which presenters and spectators are separated by at least10 feet.
- Complete reaction takes 24 hours; you may wish to have a completed version available to show the audience..
- Work in a well-ventilated area.
- Potential hazards include:
  - Acids
  - Sensitizers
  - Broken glassware
  - Inhalation hazards
  - Oxidizers
  - Spills and splashes
- Conduct your own RAMP assessment prior to presenting the activity.

Time required

Preparation: 15 minutes

Activity: 10 minutes (hands-on), 24 hours (total)

Age range

12 -18 years

Materials

- 250 mL beaker 250-mL
- Glass stirring rod
- 2 small paper clips
- 9-V battery
- Petri dish
- 2 wires with alligator clips on either end, ***or*** battery cap with alligator clip leads
- 5 g sin(II) chloride, $SnCl_2$
- 50 mL 12 M HCl solution
- 1-2 cm copper or steel wire
- Optional
  - Overhead projector
  - Clear acetate film

  or
  - Camera connected to a projection system
  - White paper

Additional materials you identified in your RAMP analysis

Prior to the activity

Customize activity to venue

1. Work in a well-ventilated area.
2. Revise procedure to adapt to your specific venue and participants.
3. List appropriate procedures for accidents, emergencies:

Identify appropriate safety practices

- Wear appropriate personal protective equipment (e.g., goggles, gloves, etc.).
- Secure loose hair, clothing.
- Prohibit eating, drinking.
- Clean work area, wash hands after activity.
- Ensure a minimum of 10 feet between presenters and audience

Prepare materials

1. Place 5 g $SnCl_2$ in beaker.
2. Add 50 mL HCl solution and stir to dissolve.

Prepare on site

1. Clip paper clips to opposite sides of the petri dish, with longer ends on the inside, nearly touching the bottom.
2. Place the petri dish on a piece of white paper for easier viewing; if using an overhead projector, place the petri dish on a clear, colorless acetate slide on the projector.
3. If desired, annotate the paper or acetate slide with the reactions described in the “Chemistry details” section.

Additional set-up for your venue and audience:

On-site activity

Step	Details	Questions for audience
Introduce the tin solution	• Show tin solution to participants • Explain that you will be creating tin metal crystals	• What do you expect tin to look like? • How does your expectation compare with the tin chloride solution?
Begin electrolysis	• Transfer tin solution to petri dish. • Attach two wires to the paper clips using the alligator clips. Connect the other ends of the wires or the battery cap to the 9-V battery. (See diagram on page 4.) • ***Optional:*** place a piece of copper or steel wire in the petri dish, with the ends pointed at the paper clips.	• What do you observe in the solution near the paper clips? • What role does each part of the set-up play in an electrical circuit? • What do you think is happening in the petri dish?
Conclude electrolysis	• Allow current to run up to 24 hours. In the meantime, show the finished version of the electrolysis • Explain how tin disproportionates to create the crystals (see “Chemistry details”)	• What do you observe in the petri dish? • What happens if you reverse the reconnect the alligator clips to opposite paper clips?
Clean up	• Neutralize solutions with sodium bicarbonate and dispose according to local regulations. • Clean and dry equipment with detergent and water. • Wash hands thoroughly.	

Chemistry details

Adjust these details to match the level of your audience.

The formation of tin crystals from the tin(II) chloride solution is an example of electrolysis. In electrolysis, an electric current induces a chemical reaction in which reactants are reduced (gains electrons) and oxidized (loses electrons), or a redox reaction.

In this activity, the $SnCl_2$ completely dissociates in water to form Sn^{2+} and Cl^- ions. These ions (plus the ions from the acid) create an electrolyte solution, or a solution capable of carrying a current. The battery powers a current that runs through the circuit created by the battery, connectingwires, paper clips, and electrolyte solution.

In the petri dish, the current drives a disproportionation reaction. Disproportionation is a type of redox reaction in which a single reactant iform both oxidized and reduced products.

Reduction takes place at the cathode, where half of the tin(II) chloride gains two electrons to become tin metal. This half of the reaction can be written as::

$Sn^{2+}_{(aq)} + 2e^- \rightarrow Sn_{(s)}$

(Cl- ions are not shown here because they neither gain nor lose elections in this process.)

Oxidization takes place at the anode, where the half of the tin(II) chloride loses two electrons to become tin(IV) chloride. This half of the reaction can be written as:

$Sn^{2+}_{(aq)} \rightarrow Sn^{4+}_{(aq)} + 2e^-$

Tin(IV) chloride is insoluble and forms the white precipitate you see at the anode.

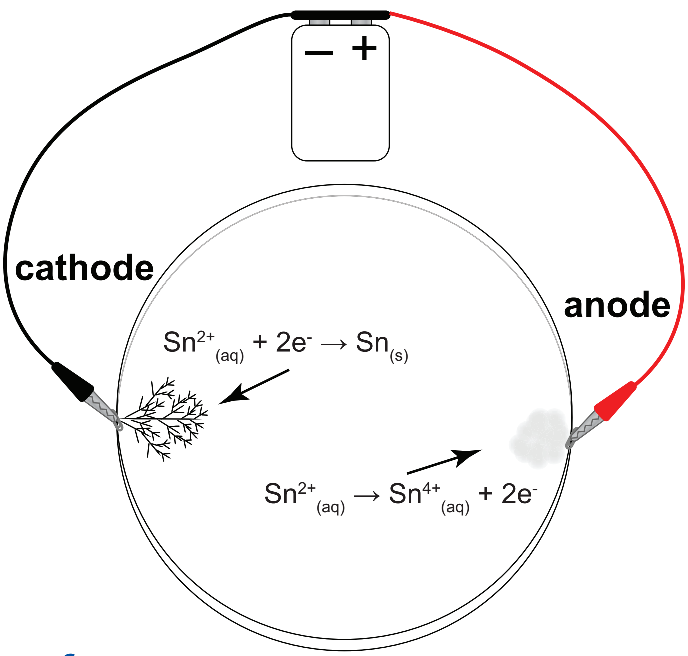
$Sn^{4+}_{(aq)} + 4Cl^- \rightarrow SnCl_{4(s)}$

The overall reaction is:

$2Sn^{2+}_{(aq)} + 4Cl^-_{(aq)} \rightarrow SnCl_{4(s)} + Sn_{(s)}$

If you added a piece of wire to the petri dish, it forms an additional electrode, with the oxidation and reduction reactions repeating at either end.

Electrolysis is a common technique for purifying metals and coating surfaces. It is also used to split water (H_2O) into hydrogen and oxygen gases for clean energy sources and is researched for other green applications.



Electrolysis of tin(II) chloride. Tin(II) chloride is reduced at the cathode to tin metal crystals. At the anode, it is oxidized to Sn^{4+}, which reacts with chloride ions present in the solution to precipitate out as tin(IV) chloride.

References

- American Chemical Society, 2023
- ACS International Student Chapter at San Diego State University–Georgia