The University of Texas at Austin
Department of Chemistry
College of Natural Sciences

Electrochemistry: Silver Plating

Performer's Version

Safety Hazards

- Personal Protective Equipment
    - Safety glasses/goggles
    - Nitrile gloves
    - Chemical & flame retardant lab coat
- Chemical Hazards
    - Silver nitrate may cause skin irritation; may cause severe skin and eye damage.

Materials

- Crystallization dish
- 2% (0.1M) Silver nitrate solution
- Copper wire
- Metal forceps
- Polypad (blue absorbent paper)

Safety Data Sheet(s)

- Silver nitrate

Procedure

1. To maximize visibility, use a document camera for this demonstration.
2. Place the polypad over the surface on which the crystallization dish will be set.
3. Set the crystallization dish in the center of the polypad.
4. Pour enough 2% Silver nitrate solution to cover the bottom of the crystallization dish.
5. Place the copper wire in the center of the dish using the metal forceps.
6. If necessary, add more silver nitrate to submerge the wire completely.
7. Allow the reaction to proceed for 15+ minutes.

Pedagogy & Supplemental Information

Electrochemistry deals with the study of chemical processes that cause electrons to move, producing an electric current. One of the common applications of electrochemistry is metal plating, where a metal is deposited onto the surface of another material, often to improve appearance, prevent corrosion, or enhance electrical conductivity. Metal plating involves redox reactions, a type of reaction where oxidation and reduction occur simultaneously. Oxidation is the loss of electrons, whereas reduction is the gain of electrons. The substance that loses electrons (undergoes oxidation) increases its oxidation state, while the substance that gains electrons (undergoes reduction) decreases its oxidation state.

The tendency of a substance to undergo oxidation or reduction is determined by its standard electrode potential, which measures the tendency of a chemical species to be reduced. Substances with higher (more positive) electrode potentials are more likely to undergo reduction, while those with lower (more negative) potentials are more likely to undergo oxidation. In the context of metal plating, this principle is critical in determining which metal will plate onto another. For example, in a redox reaction involving silver nitrate and copper wire, copper has a lower standard electrode potential compared to silver. Thus, copper tends to oxidize, losing electrons, while silver ions in the solution are reduced, gaining electrons and plating onto the copper wire.

The reaction between silver nitrate and copper wire is a single replacement reaction, also known as a displacement reaction. In this process, copper displaces silver from the silver nitrate solution due to the differences in their reactivities. Copper metal loses electrons to form copper ions, undergoing oxidation:

$$Cu\ (s) \longrightarrow Cu^{2+}\ (aq) + 2e^{-}$$

Simultaneously, silver ions (Ag^{+}) in the solution gain electrons to form silver metal (Ag), undergoing reduction:

$$Ag^{+}\ (aq) + e^{-} \longrightarrow Ag\ (s)$$

As a result of these simultaneous oxidation and reduction processes, copper dissolves into the solution as Cu^{2+} ions, while solid silver deposits onto the copper wire. This type of reaction demonstrates the displacement principle, where a more reactive metal (copper) displaces a less reactive metal (silver) from its compound. The driving force for this reaction is the difference in electrode potentials between the two metals, making it energetically favorable for copper to oxidize and silver to reduce. This process is not only fundamental in understanding electrochemical cells but also has practical applications. These electrochemical principles are widely applied in industries such as jewelry making, where silver or gold plating is used to enhance the aesthetic and durability of items. Additionally, in the electronics industry, copper and other metals are plated onto various components to improve their electrical conductivity and resistance to corrosion, ensuring reliable and long-lasting performance.