Silver Mirror Class Prize

Silverplating Demonstration

Introduction

Demonstrate an oxidation–reduction reaction that has a commercial application and use the resulting silver-mirrored flask to reward students for their achievement or creativity throughout the year.

Concepts

- Oxidation–reduction
- Reducing sugars

Materials

Acetone (optional)
Ammonium nitrate solution, NH_4NO_3, 1.5 M, 5 mL
Dextrose solution, $C_6H_{12}O_6$, 5%, 10 mL
Nitric acid, HNO_3, 6 M (optional)
Silver nitrate solution, $AgNO_3$, 0.5 M, 5 mL
Sodium hydroxide solution, NaOH, 10% (2.5 M), 10 mL
Beaker, 50-mL
Florence flask, 250-mL
Graduated cylinders, 10-mL, 4
Rubber stopper to fit flask
Wash bottle and distilled or deionized water

Safety Precautions

Sodium hydroxide solution is a corrosive liquid and is especially dangerous to the eyes. Ammonium nitrate solution is toxic by ingestion. Silver nitrate solution will stain skin and clothing. The mixed solution remaining in the flask may form an explosive mixture upon standing. Always mix the solutions fresh and dispose of the waste silverplating solution immediately after use with copious amounts of water. Wear chemical splash goggles and chemical-resistant gloves and apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Obtain a scrupulously clean 250-mL Florence flask. *Note:* A Florence flask is a flat-bottomed flask with a long neck. It is often used as a boiling flask.
2. *(Optional)* If the flask is not clean or new, clean the flask by rinsing it with distilled water, then 6 M nitric acid, followed by distilled water again, and finally acetone. Allow the flask to dry completely before beginning the activity.
3. In a small beaker, combine 5 mL of 1.5 M ammonium nitrate solution and 5 mL of 0.5 M silver nitrate solution.
4. Pour the following solutions into the Florence flask *in the order indicated:*
   - 10 mL of 5% dextrose solution
   - 10 mL of the combined ammonium nitrate/silver nitrate solution from step 3
5. Quickly pour in 10 mL of 10% sodium hydroxide solution, stopper the flask, and swirl.
6. Gently swirl the solution to mix the contents and allow the liquid to come into contact with and coat the entire surface of the flask, including the neck. Rotate and tilt the flask continuously to keep all surfaces wet.
7. Within 1–3 minutes, the entire flask should be coated with a bright and shiny silver "mirror."
8. *Immediately* pour the liquid from the flask down the drain or into a large bucket under running water. Gently, but thoroughly, rinse the flask with distilled water from a wash bottle and continue to run water down the drain for *at least 5 minutes* afterwards. *Caution:* This is an important safety precaution to prevent the formation of "fulminating silver," which is explosive if dried.

Publication No. 10153
061616

Disposal

Consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The mixture remaining in the flask after the silver mirror reaction is complete should be rinsed with excess water into a waste disposal beaker or flask set up in a central location. Test the combined waste solution for the presence of leftover silver ions by adding 1 M hydrochloric acid. If a cloudy, white precipitate of silver chloride is observed, continue adding hydrochloric acid in small amounts until no further precipitation is evident. Filter the mixture—the silver chloride may be packaged for landfill disposal according to Flinn Suggested Disposal Method #26a. The filtrate may be disposed of down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b.

Tips

- For best results, prepare the solutions fresh.
- Rinse the Florence flask with acetone before use to improve the quality of the mirror. Allow the flask to air dry to completely remove all the acetone.
- ***Always mix the solutions fresh and dispose of them immediately after use with large amounts of water***. "Fulminating silver" is a mixture of silver nitride, silver imide, and silver amide.
- The silver mirror on the inside of the flask may be protected from oxidation and mechanical stress by coating the inside of the flask with clear nail polish or shellac.
- The "silver-mirror reaction" may be used with plain glass ornament balls to prepare silver holiday ornaments. See the "Silver Ornaments Holiday Laboratory Kit" available from Flinn Scientific (Catalog Number AP7189).
- See also the student laboratory kit "Heigh-Ho Silver" available from Flinn Scientific (Catalog No. AP8981) for a microscale version of this activity.
- "Ammoniacal silver nitrate" sounds like "a maniacal" solution, but it really isn't crazy. It is used to describe a solution containing the silver–ammonia complex ion, $Ag(NH_3)_2^+$.

Discussion

Mirrors, also called "looking glasses," have been known since ancient times. The earliest mirrors were made by polishing disks of a metal such as bronze. Because of oxidation of the metal by the atmosphere and abrasion of the metal surface due to everyday use, these simple mirrors did not last very long. Better mirrors were developed by lining glass with a thin sheet of metal foil, usually silver. In 1835, the German chemist Justus von Liebig invented the silvering process used in this demonstration to plate glass with a thin layer of silver atoms. This process is still used in the manufacture of the common household mirror.

The "silver mirror reaction" used in this demonstration is a variation of the Tollens' test used by chemists to determine if an aldehyde is present in solution. Treatment of an aldehyde with "ammoniacal silver nitrate" [$Ag(NH_3)_2^+$ complex ions] in basic solution results in the formation of metallic silver via the reduction of silver ions by the aldehyde functional group. The silver plates out on the inside of the glass surface.

In this demonstration, the aldehyde functional group is supplied by dextrose, which is called a "reducing sugar" because it produces a positive test result with mild oxidizing agents such as Tollens' reagent and Benedict's reagent. The Tollens' reagent is generated *in situ* in this reaction by mixing ammonium nitrate, silver nitrate, and sodium hydroxide (Equation 1).

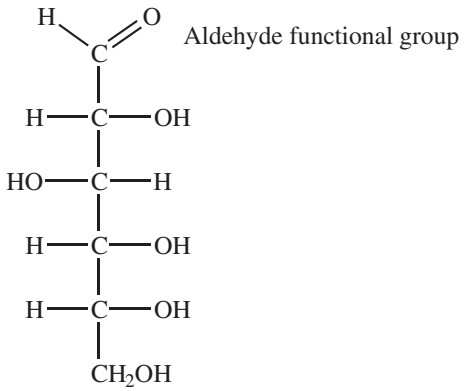
Formation of Tollens' reagent:

$$AgNO_3(aq) + 2NH_4NO_3(aq) + 3NaOH(aq) \rightarrow Ag(NH_3)_2OH(aq) + 3NaNO_3(aq) + 2H_2O(l) \quad \textit{Equation 1}$$

Tollens' reagentReduction of Tollens' reagent:

$$\underset{\textit{Aldehyde}}{R\text{-}CHO(aq)} + 2Ag(NH_3)_2OH(aq) \rightarrow R\text{-}COONH_4(aq) + 2Ag(s) + 3NH_3(aq) + H_2O(l) \quad \textit{Equation 2}$$

Structure of dextrose:



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 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Reference

This activity was adapted from *Oxidation and Reduction*, Volume 16 in the *Flinn ChemTopic™ Labs* series, Cesa, I., Editor; Flinn Scientific, Inc., Batavia, IL (2004).

Materials for *Silver Mirror Class Prize—Silverplating Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
GP3085	Flask, Boiling, Flat Bottom, Florence, Borosilicate Glass
S0025	Silver Nitrate, 25 g

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