Silver Mirrors

Copper, Silver and Gold Redox Reactions

FLINN SCIENTIFIC CHEMFAX!

Introduction

Reward student achievement or creativity with the "silver mirror award," a beautiful silver-mirrored flask that you create in the lab by the reduction of silver ions with dextrose. Simply combine four solutions in a flask, swirl, and *voilá*—a thin, highly reflective silver coating plates out on the inside of the flask. The process "mirrors" the way silver mirrors are actually produced.

Concepts

- Oxidation–reduction
- Reducing sugars

Materials

Acetone, 10 mL
Ammonium nitrate solution, NH_4NO_3, 1.5 M, 5 mL
Dextrose solution, $C_6H_{12}O_6$, 5%, 10 mL
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
Nail polish, clear (optional)
Rubber stopper to fit flask
Wash bottle and distilled 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. For best results, rinse the Florence flask with acetone before use. Allow the flask to air dry completely to remove all the acetone.
2. In a 50-mL beaker, combine 5 mL of 1.5 M ammonium nitrate solution and 5 mL of 0.5 M silver nitrate solution. Use a clean 10-mL graduated cylinder to measure each solution.
3. Pour the following solutions into the Florence flask in the order indicated:
   a. 10 mL of 5% dextrose solution
   b. 10 mL of the combined ammonium nitrate/silver nitrate solution from step 2.
4. Quickly pour 10 mL of 10% sodium hydroxide solution into the flask and stopper the flask.
5. 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.
6. Within 1–3 minutes, the entire flask should be coated with a bright and shiny silver "mirror."
7. Immediately pour the liquid from the flask down the drain under running water.
8. Gently, but thoroughly, rinse the flask with distilled water from a wash bottle and continue to run water down the drain for at least five minutes. *Caution:* This is an important safety precaution to prevent the formation of silver fulminate, which is explosive if dried.

Disposal

Consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the

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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

- The Silver Flask Award—Demonstration Kit (Catalog No. AP6893) is available from Flinn Scientific and contains enough solutions to prepare at least five silver mirror flasks. Only one Florence flask is provided in the kit. A Florence flask is a flat-bottomed flask with a long neck. It is often used as a boiling flask. Other types of glassware may also be substituted. Small, disposable test tubes are perfect for end-of-the-year mementos for the students.
- All glassware used in this demonstration must be scrupulously clean in order for the silver mirror to adhere to the glass surface. If the desired glassware 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.
- Always mix the solutions fresh and dispose of them immediately after use with large amounts of water.
- 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 to prepare silver holiday ornaments. See the *Silver Ornaments—Holiday Laboratory Kit* available from Flinn Scientific (Catalog No. AP7189) or downsize to the microscale level using small, disposable culture tubes (12 × 75 mm) available from Flinn Scientific (Catalog No. AP8981).

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 by mixing ammonium nitrate, silver nitrate, and sodium hydroxide (Equation 1). Reduction of dextrose by Tollens' reagent generates silver metal, ammonia, and an oxidized sugar derivative called gluconic acid (Equation 2).

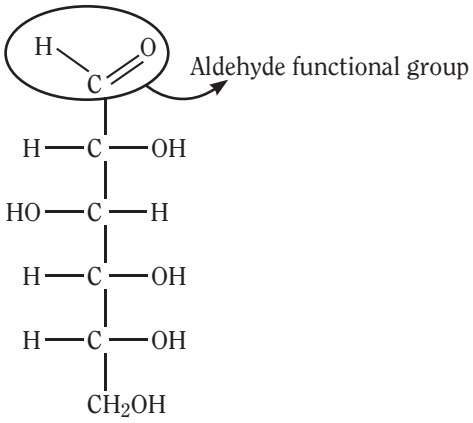
Formation of Tollens' reagent:

$$AgNO_3(aq) + 2NH_4NO_3(aq) + 3NaOH(aq) \rightarrow \underset{\textit{Tollens' reagent}}{Ag(NH_3)_2OH(aq)} + 3NaNO_3(aq) + 2H_2O(l) \qquad \textit{Equation 1}$$

Reduction of Tollens' reagent:

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

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
Constancy, change, and measurement
Content Standards: Grades 5– 8
Content Standard B: Physical Science; properties and changes of properties in matter
Content Standard G: History and Nature of Science; science as a human endeavor
Content Standards: Grades 9–12
Content Standard B: Physical Science; chemical reactions
Content Standard G: History and Nature of Science; science as a human endeavor

Reference

This activity was adapted from *Flinn ChemTopic™ Labs*, Volume 17, *Oxidation and Reduction*, Cesa. I., Editor; Flinn Scientific: Batavia IL (2004).

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Silver Mirrors* activity, presented by Kathleen Dombrink, is available in *Copper*; *Silver and Gold Redox Reactions* and in *Favorite Holiday Demonstrations*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Silver Mirrors* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *The Silver Flask Award—Demonstration Kit* available from Flinn Scientific. Similar activities include the *Silver Ornaments—Holiday Laboratory Kit* and *Make Your Own Silver Mirror—A Microscale Lab*. Materials may also be purchased separately.

Catalog No.	Description
AP6893	The Silver Flask Award—Demonstration Kit
AP7189	Silver Ornaments—Holiday Laboratory Kit
AP8981	Make Your Own Silver Mirror—A Microscale Lab
A0009	Acetone, 500 mL
S0261	Silver Nitrate Solution, 0.5 M, 100 mL
S0074	Sodium Hydroxide, 100 g
A0241	Ammonium Nitrate, 100 g
D0005	Dextrose, 500 g
GP3085	Flask, Florence, 250-mL

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