

Reducing Sugars Give Silver Mirrors

Reactions of Organic Compounds



Introduction

Four colorless solutions are poured into a round-bottom flask. After several seconds of swirling, a shiny silver mirror forms on the inside of the flask.

Concepts

- Oxidation-reduction reactions
- Aldehyde reactivity (Tollens' test)
- Reducing sugars/carbohydrates

Materials

Ammonium nitrate, NH_4NO_3 , 6.0 g
Ethyl alcohol, $\text{C}_2\text{H}_5\text{OH}$, 95%, 10 mL

Silver nitrate, AgNO_3 , 4.0 g
Sodium hydroxide, NaOH , 10 g

Sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, 5 g

Tartaric acid, $\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H}$, 0.6 g

Water, distilled or deionized

Balance, 0.1-g precision

Beaker, 50-mL

Beaker, 1000-mL (for waste)

Erlenmeyer flasks, 125-mL or 250-mL, 3 (to prepare the solutions)

Flask, round-bottom, 500-mL

Flask stand, round-bottom (optional)

Graduated cylinders, 25-mL, 2

Graduated cylinders, 10-mL, 2

Hot plate

Rubber stopper to fit 500-mL flask

Stirring rods

Safety Precautions

Ammonium nitrate is a strong oxidizer, may explode if heated; slightly toxic by ingestion. Ethyl alcohol is a dangerous fire and explosion risk; contains denaturants that make it poisonous and cannot be made non-poisonous. Keep away from open flames. Silver nitrate is corrosive; causes burns; avoid contact with eyes and skin; will stain skin and clothing; highly toxic. Sodium hydroxide is corrosive; causes burns; much heat evolves when added to water; very dangerous to skin and eyes. Wear chemical-resistant apron, chemical-resistant gloves and chemical splash goggles. Please review current Material Safety Data Sheets for additional safety, handling and disposal information.

Immediately dispose of the unreacted mixture. Explosive fulminating silver compounds may form if the unreacted mixture is allowed to stand.

Preparation

- Solution A:** To prepare 100 mL, add 5 g of sucrose and 50 mL of distilled or deionized water in a 125-mL Erlenmeyer flask. Add 0.6 g of tartaric acid. Heat the solution to a boil for approximately 10 minutes—this ensures that the solid is completely dissolved. Allow the solution to cool. Add 10 mL of ethyl alcohol as a stabilizer. Dilute the solution to a final volume of 100 mL with distilled or deionized water.
- Solution B:** To prepare 50 mL, dissolve 4.0 g of silver nitrate and 6.0 g of ammonium nitrate in 50 mL of distilled or deionized water. Once dissolved, dilute to a final volume of 100 mL with distilled or deionized water.
- Solution C:** To prepare 100 mL, dissolve 10 g of sodium hydroxide in 75 mL of distilled or deionized water. Once dissolved, dilute to a final volume of 100 mL with distilled or deionized water. *Caution:* Heat is generated when sodium hydroxide and water are mixed. Prepare this solution in an ice-water bath.

Procedure

1. Fill a 1000-mL beaker three-quarters full of water.
2. Add 20 mL of Solution A into a scrupulously clean 500-mL round-bottom flask. Place the round-bottom flask on a round bottom flask stand or other stabilizing stand.
3. Into a 500-mL flask, add 20 mL of Solution B.
4. Quickly add 20 mL of Solution C to the 500-mL flask. Stopper the flask and swirl the solution to coat the entire inside of the flask. Place a paper towel over the rubber stopper to soak up any solution that may leak from the flask as it is swirled. Wear chemical-resistant gloves during this step.
5. Rotate and tilt the flask to keep all surfaces wet for about one minute. It will take approximately one minute of continuous swirling and tilting to form a fine silver mirror on the inside walls of the flask.
6. Immediately after the mirror has formed, pour the remaining solution in the flask into the 1000-mL water-filled waste beaker. Rinse the flask thoroughly with water several times. This step is very important and must be done immediately to prevent the possible formation of an explosive mixture. Follow appropriate disposal procedures.

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. Excess ammonium nitrate solution and Solution A may be disposed of according to Flinn Suggested Disposal Method #26b.

Tips

- The flask must be scrupulously clean. A new flask works the best. Used flasks may have scratches that tend to cause the silver layer to peel. Clean flasks with 6 M nitric acid. Rinse several times with distilled water and once with acetone. Allow sufficient time for the glassware to dry completely.
- Volumetric and Erlenmeyer flasks may be used as substitutes for the round-bottom flask.
- Be prepared to dispose of the final solution and thoroughly rinse out the flask immediately at the completion of the demonstration.
- The silver coating on the inside of the flask may be protected from oxidation and mechanical stress by coating it with either a clear varnish or paint. The coating may be applied by pouring about 50 mL of water-based varnish or paint into the flask, turning the flask to coat its entire interior surface, pouring out the excess, and allowing the coating to dry.

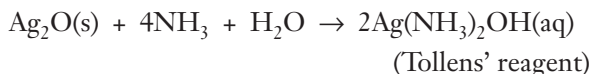
Discussion

In 1835, Justus von Liebig (1803–1873), a German chemist, was the first person to use the silvering process to coat a plate of glass and turn it into a mirror. This process is still used today to manufacture household mirrors.

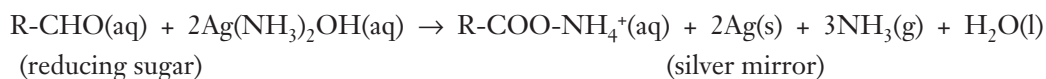
The silvering process relies on the same chemistry as the Tollens' test for the detection of aldehydes in solution. Treatment of an aldehyde with a solution of silver nitrate in ammoniacal sodium hydroxide produces a silver mirror on a glass surface. Sucrose is used to reduce silver ions in Tollens' reagent to silver metal, which is then deposited on the inside of the flask. This process does not require any electricity and is called "electroless plating."

Reducing Sugars Give Silver Mirrors *continued*

Formation of Tollens' Reagent:



Reduction of Tollens' Reagent:



Tartaric acid is added as an antioxidant for the sugar solution to prevent it from oxidizing during the heating process. The brown precipitate that forms when the four solutions are mixed is silver oxide.

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
Form and function

Content Standards: Grades 5–8

Content Standard B: Physical Science, properties and changes of properties in matter
Content Standard E: Science and Technology

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions
Content Standard E: Science and Technology

Acknowledgment

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Reference

Kemp, M. J. *Chem. Educ.* **1981**, *58*, 655.

Summerlin, L. R.; Ealy, J. L., Jr. *Chemical Demonstrations*, American Chemical Society: Washington, DC, 1985; p. 88.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Reducing Sugars Give Silver Mirrors* activity, presented by Jamie Benigna, is available in *Reactions of Organic Compounds*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

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

Materials required to perform this activity are available in the *Silver Ornaments* and *The Silver Mirror Award* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP6893	The Silver Mirror Award
AP7189	Silver Ornaments
A0241	Ammonium Nitrate, 100 g
E0012	Ethyl Alcohol, anhydrous, 500 mL
S0134	Sucrose, Reagent, 500 g
S0274	Silver Nitrate, 5 g
S0074	Sodium Hydroxide, 100 g
T0054	L-Tartaric Acid, 100 g
W0001	Water, Distilled, 1 gallon
GP4010	Round Bottom Flask, Pyrex®

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