Colorful Stalactites and Stalagmites

Double Replacement Reactions

Introduction

Introduce stalactite and stalagmite formation by performing this colorful, easy-to-follow demonstration.

Science Concepts

- Stalactites
- Stalagmites
- Precipitates
- Double replacement reactions

Materials

Cobalt nitrate, $Co(NO_3)_2 \cdot 6H_2O$, ~10 g
Cupric sulfate, $CuSO_4 \cdot 5H_2O$, ~10 g
Sodium hydroxide solution, NaOH, 0.25 M, ~1 L
Beakers, tall-form, 500-mL, 2
Paper towel, white
Scissors, heavy-duty (optional)
Wire gauze, 5″ × 5″, 2

Safety Precautions

Cobalt nitrate is an oxidizer and a fire risk in contact with organic material. It is moderately toxic and a possible carcinogen as a fume or dust. Cupric sulfate is moderately toxic by ingestion and inhalation. The sodium hydroxide solution is a corrosive and irritating solution. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Instruct students viewing the demonstration not to touch or handle the reaction mixtures or beakers. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Place the wire screen over the top of the beaker.
2. Shape the wire to form a trough that will extend down into the beaker approximately 1″ (see Figure 1). This trough will hold the cupric sulfate and cobalt nitrate crystals.
3. To make a 0.25 M solution of sodium hydroxide, simply dilute 1 M sodium hydroxide in a 1-to-3 ratio with distilled water. For example, use 250 mL of 1 M sodium hydroxide and 750 mL of distilled or deionized water to make 1 L of 0.25 M sodium hydroxide solution.

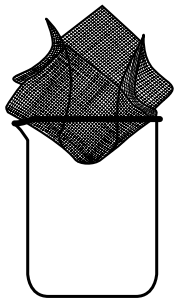

Figure 1.

Procedure

1. Place the beaker on a white paper towel on a level surface. Fill it nearly full with 0.25 M sodium hydroxide solution, NaOH.
2. Place the pre-shaped wire gauze trough on top of the beaker (if it is not on top of the beaker already). The wire gauze should hang down about 1″ into the sodium hydroxide solution.
3. Place approximately 10 g of cupric sulfate crystals in the wire gauze trough.
4. Within seconds, observe the double-replacement reaction that produces the colorful stalactites and stalagmites.
5. Repeat steps 1–4 in a clean beaker, substituting cobalt nitrate for the cupric sulfate.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The copper-containing waste solution may be disposed of according to Flinn Suggested Disposal Method #26b. The cobalt containing the waste solutions may be disposed of according to Flinn Suggested Disposal Method #27f.

Tips

- Hydrometer cylinders may also be used in place of beakers. This will allow longer stalactites to form.
- The crystals react chemically with the sodium hydroxide solution to form insoluble precipitates. The beaker must be left completely undisturbed in order for some of the strands to completely reach the bottom.
- The wire gauze may be trimmed to fit your beakers, if desired.

Discussion

As groundwater drips through caves, elaborate formations develop. These cave formations and deposits are called dripstone and can be classified into two unique groups: stalactites and stalagmites. *Stalactites* are icicle-like formations that hang from the ceilings of caves ("c" for ceiling). When groundwater drips through and reaches the air in the cave, some of the dissolved carbon dioxide escapes from the drop and calcite ($CaCO_3$) begins to precipitate. The calcite is deposited as a ring around the water drop. Drop after drop a very small amount of calcite is left behind. Eventually a hollow tube made of limestone is created. Water continues to move through this tube and continues to add calcite to the stalactite. The stalactite can be appropriately described as a soda straw at this point. The soda straw becomes plugged and water is forced to flow outside the stalactite. Calcite deposits are then left on the outside of the stalactite and the familiar conical or icicle shape forms.

Formations that occur on the floor of a cavern are known as *stalagmites* ("g" for ground). The water that supplies calcite to the growing stalactite splatters on the floor of the cave. As a result, stalagmites are formed and grow upwards towards the ceiling of the cave. Stalagmites are often not uniform in shape and are more massive than stalactites because of this splattering.

The precipitates seen in this demonstration are produced by a series of double-replacement reactions. Each of the chemical reactions results in the formation of a precipitate. The reactions can be used to illustrate a variety of chemical concepts ranging from accelerated stalactite and stalagmite formation to the production of precipitates via double replacement reactions.

Reaction in beaker 1:

Initially a blue-green salt is formed:

$$Cu^{2+} + 2OH^- \rightarrow Cu(OH)_2 \text{ blue-green ppt}$$

An outer crust of black cupric oxide eventually forms:

$$Cu(OH)_2 \rightarrow CuO \text{ black ppt} + H_2O$$

Reaction in beaker 2:

Initially the blue basic salt is formed:

$$Co^{2+} + OH^- + NO_3^- \rightarrow Co(OH)NO_3 \text{ (blue ppt)}$$

Upon addition of excess reagent, the basic salt is converted into pink cobalt (II) hydroxide:

$$Co(OH)NO_3 + OH^- \rightarrow Co(OH)_2 \text{ (pink ppt)} + NO_3$$

Some of the precipitate passes into solution. The insoluble cobalt(II) hydroxide is slowly transformed into the brownish-black cobalt(III) hydroxide:

$$4Co(OH)_2 + O_2 + 2H_2O \rightarrow 4Co(OH)_3 \text{ (black ppt)}$$

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
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standard D: Earth Science, structure of the Earth system
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter
Content Standard D: Earth and Space Science, energy in the earth system, origin and evolution of earth system

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Colorful Stalactites and Stalagmites* activity, presented by Jamie Benigna, is available in *Double Replacement Reactions* and in *Precipitation Reactions and Solubility Rules*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Colorful Stalactites and Stalagmites* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Colorful Stalactites and Stalagmites—Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP6538	Colorful Stalactites and Stalagmites—Demonstration Kit
C0105	Copper(II) Sulfate, Crystal, 500 g
C0207	Cobalt Nitrate, Reagent, 25 g
S0148	Sodium Hydroxide, 1 M, 500 mL
AP5352	Wire Gauze, Steel, 5" × 5"

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