Sodium Silicate Solution

The Colorful Silicate Garden

Introduction

In a matter of seconds, columns of various colors sprout up from the bottom of a beaker containing a clear liquid. The crystals form like stalagmites in a cave and will continue to grow for several days. This beautiful crystal garden is fascinating to watch.

Concepts

- Metallic salts
- Ions
- Crystal formation

Materials (for each demonstration)

Aluminum chloride, $AlCl_3 \cdot 6H_2O$, 2–3 g
Cobalt(II) nitrate, $Co(NO_3)_2 \cdot 6H_2O$, 2–3 g
Copper(II) chloride, $CuCl_2 \cdot 2H_2O$, 2–3 g
Iron(III) chloride, $FeCl_3 \cdot 6H_2O$, 2–3 g
Sodium silicate solution (water glass), 225 mL
Water, tap, 375 mL
Beaker, 1000-mL, or other equivalent glass container
Graduated cylinder, 500-mL
Plastic wrap
Sand, clean (optional)
Scoops or spatulas, 4
Stirring rod, glass

Safety Precautions

Do not use anhydrous aluminum chloride. Use only aluminum chloride hexahydrate ($AlCl_3 \cdot 6H_2O$). Iron(III) chloride is a skin and tissue irritant and is corrosive. Copper(II) chloride is toxic by ingestion and inhalation. Cobalt(II) nitrate is an oxidizer and a fire risk in contact with organic material, and is moderately toxic. Sodium silicate solution is a body tissue irritant. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Optional: Cover the bottom of a 1000-mL beaker with sand. The sand will prevent the crystals from sticking to the bottom of the beaker and will make cleanup much easier.
2. Using a 500-mL graduated cylinder, measure out 375 mL of water and transfer it to the beaker. Transfer it slowly so the sand is not disturbed.
3. Using a 500-mL graduated cylinder, measure out 225 mL of sodium silicate solution and transfer it to the beaker. Again, transfer slowly.
4. Gently stir the solution with a glass stirring rod.
5. With the use of scoops or spatulas, sprinkle about ¼ teaspoon (2–3 g) of each of the metallic salts (aluminum chloride, iron(III) chloride, copper(II) chloride and cobalt(II) nitrate) into the beaker. Sprinkle the crystals out evenly and use only small crystals.
6. Cover the beaker with plastic wrap.
7. Observe the colorful silicate crystals. They will start to grow in seconds and will continue for several days. Notice that the crystals formed by aluminum chloride are white, iron(III) chloride are brown, copper(II) chloride are light blue-green and cobalt(II) nitrate are dark blue.
8. After several days, the sodium silicate solution may become cloudy. You may carefully replace the solution with tap water to preserve the colorful silicate garden, providing you did not use sand in step 1.

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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 colorful silicate garden may be flushed down the drain with excess water according to Flinn Suggested Disposal Method # 26b. The sand should be rinsed off and disposed of in the trash according to Flinn Suggested Disposal Method #26a.

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 Standards: Grades 9–12
Content Standard B: Physical Science, structure of atoms, structure and properties of matter

Tips

• The sand used must be clean. Dirty sand will cause the crystal garden to be cloudy. Sand will also give the garden some topography (the garden will have a more rugged terrain). The crystal garden will be much more fragile if sand is used.

• If sand is not used, the sodium silicate solution may be replaced with water after the crystals have stopped growing. The garden can then be enjoyed for a longer period of time.

• When the solid salts are added to the solution, they may tend to float and may need to be pushed down with the spatula.

Discussion

When the various salts are added to the sodium silicate solution, the salts start to dissolve releasing metallic ions. The metallic ions combine with the silicate ions to form a membrane of insoluble silicates around the various salt crystals.

The crystals grow upward because the membrane that forms is semipermeable. The concentration inside the membrane is greater than the concentration outside the membrane. A process called osmosis allows the water to enter the membrane to equalize the concentrations. The membrane breaks upward due to the increased pressure of water on the inside walls of the membrane. The break in the membrane causes more salt to be exposed to the silicate solution and thus the membrane continues to grow.

References

Shakhashiri, Bassam Z., *Chemical Demonstrations: A Handbook for Teachers of Chemistry*, Volume 3. Madison, Wisconsin: The University of Wisconsin Press, 1989.

Sumerlin, Lee R. and James L. Ealy, Jr., *Chemical Demonstrations: A Sourcebook for Teachers*, Volume 1. Washington D.C.: American Chemical Society, 1988.

Materials for *Sodium Silicate Solution—The Colorful Silicate Garden* are available from Flinn Scientific, Inc.

This activity is also available as a chemical demonstration kit, with enough chemicals to perform the demonstration seven times and a reproducible student worksheet.

Catalog No.	Description
AP4424	The Colorful Silicate Garden—Chemical Demonstration Kit
S0102	Sodium Silicate Solution, 500 mL
A0225	Aluminum Chloride Hexahydrate, 100 g
F0006	Iron(III) Chloride, 100 g
C0281	Copper(II) Chloride, 100 g
C0207	Cobalt Nitrate, 25 g

Consult the Flinn Scientific website for current prices.