Crystal Garden

Laundry Bluing

Introduction

No green thumb required! Enjoy growing crystal gardens with household-type chemicals.

Concepts

- Crystal formation
- Evaporation
- Capillary action

Materials (for each student group)

Household ammonia, 1 tablespoon	Beaker, 250-mL
Laundry bluing, 6 tablespoons	Pieces of charcoal briquettes, coal, sponge or other porous material
Sodium chloride, NaCl, 3 tablespoons	Shallow, wide-mouth dish
Vegetable dyes (food coloring)	Stirring rod
Hot water, 6 tablespoons	Tablespoon

Safety Precautions

Household ammonia is toxic by ingestion and inhalation; both liquid and vapor are extremely irritating, especially to eyes. When handling the laundry bluing and crystal growing solution, use caution to prevent spilling on clothes. Do not use charcoal soaked in lighter fluid. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Place several (3–5) pieces of charcoal briquettes, coal, sponge or other porous material in a shallow bowl.
2. In a 250-mL beaker, measure out 3 tablespoons of sodium chloride. Add 6 tablespoons of hot water. Stir to dissolve.
3. Add 6 tablespoons of laundry bluing and 1 tablespoon of household ammonia to the salt solution. Stir.
4. Pour all of the solution over the porous material. The solution should not completely cover the porous material.
5. Place several drops of food coloring on the surface of the porous material.
6. Place the bowl in a place where it will not be disturbed. The crystals will start to form in 1 to 12 hours depending on the rate of evaporation of the solution. Do not move or touch the crystal garden once the crystals start to grow. The crystals are very fragile.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The crystal garden may be disposed of according to Flinn Suggested Disposal Method #26a.

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NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS1 Matter and its Interactions
  - PS1.A: Structures and Properties of Matter
- MS-ESS2 Earth's Systems
  - ESS2.C: The Roles of Water in Earth's Surface

Disciplinary Core Ideas: High School
- HS-PS1 Matter and its Interactions
  - PS1.A: Structures and Properties of Matter
- HS-ESS2 Earth's Systems
  - ESS2.C: The Roles of Water in Earth's Surface Processes

Science and Engineering Practices
- Planning and Carrying Out Investigations
- Developing and using models

Crosscutting Concepts
- Patterns
- Cause and effect
- Structure and function

Tips

- Charcoal briquettes work extremely well as the porous material. Crystals may even start to grow in about an hour.
- Using hot water aids in dissolving the salt and also allows for more rapid crystal formation.
- Have the students try to grow crystal gardens from solutions in which one of the three ingredients is missing. Ask them to analyze their results.

Discussion

The porous material allows for capillary action; that is, the solution will rise up through the porous material. This allows for the solution to be dispersed over a large surface area which speeds up the evaporation of the liquid. As the liquid evaporates, crystals will start to form. Humidity and temperature will affect the rate of evaporation. Generally, rapid evaporation will result in the formation of small crystals while slow evaporation will result in large crystals.

The bluing solution contains two forms of the blue pigment, Prussian blue. The "soluble" form of Prussian blue, $KFe^{III}Fe^{II}(CN)_6$ is actually a stable colloidal suspension (a solid dispensed in a liquid), while the insoluble form $Fe^{III}{}_4[Fe^{II}(CN)_6]_3 \cdot xH_2O$ settles out of solution upon standing.

The bluing mixture is combined with an ammonia solution (NH_3) and a saturated solution of sodium chloride (NaCl). The fluffy white crystals that form are believed to be ammonium chloride (NH_4Cl) and two forms of ferrous ferrocyanide, $KNaFe^{II}Fe^{II}(CN)_6$ and $Na_4Fe^{II}{}_4[Fe^{II}(CN)_6]_3$. The latter two compounds are produced from the reduction of the Prussian blue by ammonia in solution.

$$KFe^{III}Fe^{II}(CN)_6 + e^- + Na^+ \rightarrow KNaFe^{II}Fe^{II}(CN)_6 \qquad \textit{Equation 1}$$

$$Fe^{III}{}_4[Fe^{II}(CN)_6]_3 + 4e^- + 4Na^+ \rightarrow Na_4Fe^{II}{}_4[Fe^{II}(CN)_6]_3 \qquad \textit{Equation 2}$$

$$2NH_3 + 6OH^- \rightarrow N_2 + 6H_2O + 6e^- \qquad \textit{Equation 3}$$

References

McDuffie, Jr., Thomas E., and Anderson, Jacqueline, Chemical *Experiments from Daily Life.* Portland, ME: J. Weston Walch, 1980.

Katz, David A., *Chemistry in the Toy Store*, 5th Edition. Community College of Philadelphia, Philadelphia, PA, 1990.

Materials for the *Crystal Garden* are available from Flinn Scientific, Inc.

Catalog No.	Description
B0235	Flinn Bluing Solution, 500 mL
S0063	Sodium Chloride, 500 g
A0038	Ammonia, Household, 1 L
C0252	Charcoal, Wood, Lump, 500 g
V0003	Vegetable Dyes, Set
AP1279	Weighing Dishes, Disposable

Consult the Flinn Scientific website for current prices.