Ghost Crystals

Introduction

A vial appears to contain only water and a small string "noose" hanging down into it. When the string is lifted out, a large shiny crystal is found to be tied up in the noose. When the string is lowered back into the water, the crystal again becomes invisible!

Chemical Concepts

- Polymer gel
- Superabsorbent polymers
- Index of refraction

Materials

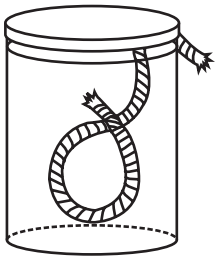
Glass jar with lid, approx. 1-L
Ghost crystals, 5–10
Distilled or deionized water, 1 L
String, 1–2 mm in diameter
Clear plastic bottle (or vial) or 100-mL beaker
Clean dish

Safety Precautions

Ghost crystals are not considered hazardous. However, if ingested, they may harm the gastrointestinal tract. Wear goggles whenever working with chemicals, heat or glassware in the lab. Wash hands thoroughly with soap and water after handling the ghost crystals. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Place 5–10 of the ghost crystals into the glass jar and fill it with distilled or deionized water to within about 3 cm of the top. Place the lid on the jar and let it stand undisturbed for a few hours.
2. When the crystals have grown to the point where they appear essentially invisible, pour out four or five of them into a clean dish. Although they look like chunks of glass, the crystals are actually quite rubbery like Jell-O.®
3. Choose one of the crystals and, touching it as little as possible, tie a string around it snugly, but not so tight that it squeezes or breaks the crystal in half. This will take some practice!
4. Fill a small bottle, vial or beaker with distilled or deionized water, pick up the crystal by the string, and lower it into the container. The crystal will seem to disappear!
5. Show your students the container of water with the "empty" noose inside. Let them examine it closely. Then lift out the string and show them the tied-up crystal. Demonstrate that the crystal disappears again when it is placed back into the water.



Disposal

Dispose of ghost crystals in the trash according to Flinn Suggested Disposal Method #26a. Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste.

Tips

- Because oils from your skin may be adsorbed onto the ghost crystal and cloud its surface, wash hands thoroughly before touching the crystal and handle the crystal as little as possible.
- If bubbles form inside the crystals, place the vial in the refrigerator for a few hours to dissolve the excess gas. After removing the vial from the refrigerator, allow the contents to warm to room temperature. As the temperature of the water increases, any dissolved gas tends to exit at the water's surface rather than go back into the crystals.
- A benefit of using a plastic vial with a lid is that you can hot-melt glue the string onto the inside of the lid, snap the vial closed, and pass it around the classroom quite easily.

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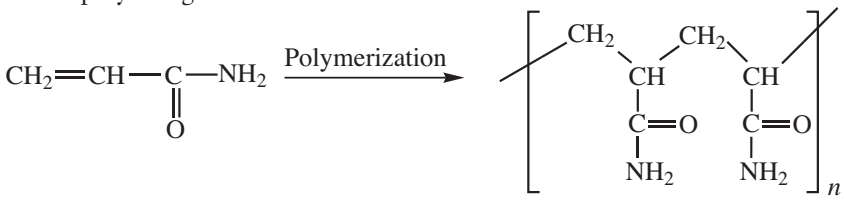
- Many students will probably want to observe the crystal up close. Pass around a Petri dish containing a few swollen ghost crystals, along with some of the anhydrous starting crystals, to show the incredible difference in size.
- The water-logged ghost crystals may develop mold upon prolonged storage.

Discussion

"Ghost crystals" are composed of a hydrophilic (water-loving), cross-linked polymer called polyacrylamide. The polymer contains thousands of acrylamide units that have been joined together by a chemical reaction (Equation 1). The numerous, polar C=O and $-NH_2$ groups in polyacrylamide form strong hydrogen bonds to water molecules, and the polymer readily absorbs large amounts of water to form a polymer gel.



Acrylamide *Polyacrylamide* *Equation 1*

The polymer chains in polyacrylamide ghost crystals are highly cross-linked, which means that they have been "tied together" into a giant, three-dimensional network by the formation of covalent bonds between the individual polymer chains. The network structure is very large, and there is plenty of "empty space" for absorption of water molecules. When the anhydrous ghost crystals are placed in water, they readily absorb water and swell to many times their original size.

Polyacrylamide and sodium polyacrylate, the material used in disposable diapers, are examples of superabsorbent polymers. The main uses of polyacrylamide are in municipal and industrial water treatment—polyacrylamide is used as a flocculant to clarify water by increasing the rate of settling of suspended solids. "Water gel crystals" such as ghost crystals are sold commercially for use in gardening and as watering aids for indoor plants. (A copolymer of polyacrylamide is also used in the popular "Grow Beast" toys.) Polyacrylamide ghost crystals will absorb approximately 400 times their weight in water to form crystal-clear, gelatinous solids. Because a swollen ghost crystal is made up almost entirely of water, its index of refraction is essentially the same as that of water, and the ghost crystal "disappears" when placed in water. When the swollen ghost crystal is removed from the water, it instantly becomes visible again because the index of refraction of air is much different from that of the crystal or water.

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

Acknowledgments

Special thanks to Robert Becker, Kirkwood High School, Kirkwood, Missouri for developing the Ghost Crystal activity. Bob Becker first learned about Ghost Crystals from Ed Escudero, Summit Country Day School, Cincinnati, Ohio. Ed shows his students a jar full of what appears to be normal water—they cannot see that it is packed full of the invisible hydrated crystals. He tells them that the water coming out of the tap seems especially "hard" today, and then proceeds to pour out a cupful of water so hard that it falls out of the jar in chunks! Thanks also to Ron Crampton, Westside High School, Omaha, Nebraska for contributing information about ghost crystals.

Materials for *Ghost Crystals* are available from Flinn Scientific, Inc.

Catalog No.	Description
G0050	Ghost Crystals, 100 g
G0052	Ghost Crystals, 500 g

Consult the Flinn Scientific website for current prices.