GROW YOUR OWN CRYSTAL TREE OR CRYSTAL GARDEN

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Crystals can be grown at home using a solution of sodium chloride, ammonia, water, and laundry bluing. The crystals can be grown on a paper tree, made from white or green colored blotter paper (see Figure 1), or as a crystal garden "grown" on a charcoal briquette, a piece of lava rock (used in a gas barbecue), or a piece of coal. To give the crystals some color, drops of food colors can be placed on the growing material, in advance, and allowed to dry before use.

The chemistry of the crystal garden appears to be complex. Essentially, it appears that a complex compound known as Everitt's salt, $K_2Fe^{II}Fe^{II}(CN)_6$, is the substance that makes up the fluffy white crystals that are observed in the experiment.

This compound is formed from one of the components of the process, laundry bluing. Laundry bluing is used to whiten fabrics which have turned yellow or gray as a result of repeated -washings. It is composed of a colloidal solution of Prussian blue which is used as a blue pigment that makes fabrics appear white. Prussian blue is made by reacting potassium ferrocyanide with iron(III) sulfate:

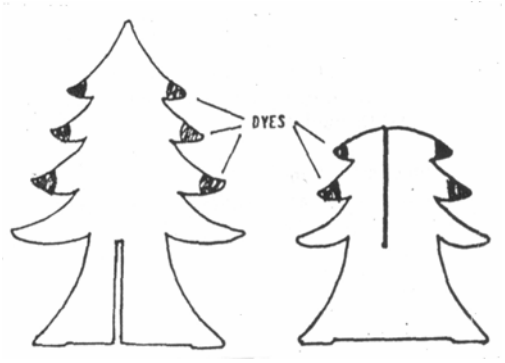

Figure 1. One possible shape for a crystal tree. Slits are cut in the pieces for assembly.

$$3\ K_4Fe(CN)_6 + 2\ Fe_2(SO_4)_3 + x\ H_2O \rightarrow Fe_4[Fe(CN)_6]_3 \cdot xH_2O + 6\ K_2SO_4$$

Note: x = 14-16

Prussian blue is formed as a precipitate (it is not soluble in water). This reaction, however, is the ideal case when the reaction occurs very slowly. If formed quickly, as is usually the case, the Prussian blue is more likely to have the formula $K[Fe^{II}Fe^{III}(CN)_6]\ xH_2O$. It contains iron in both the +2 and +3 oxidation states, as denoted by the Roman numerals. The intense color is due to charge-transfer from Fe^{II} to Fe^{III}. (There is no color if both iron atoms are in the same oxidation state.)

It is suspected that during the evaporation of solvent and resulting crystallization there is probably a reduction of the Prussian blue forming white $KNaFe^{II}Fe^{II}(CN)_6$ where additional K^+ ions would fill in the crystal lattice due to the openings left by reduction of Fe^{III} to Fe^{II}. Since there are few additional potassium ions in solution, the lattice is probably filled by the Na^+ ions from the salt forming $KNaFe^{II}Fe^{II}(CN)_6$ which should also be white in color.

PROCEDURE

1. Materials Needed:

sodium chloride, NaCl - table salt, Kosher salt, or pickling salt (plain - not iodized)
ammonia solution, NH_3 (regular household ammonia - not sudsy type)
laundry bluing, Mrs. Stewart's* Liquid Bluing is preferred (Mrs. Stewart's* Liquid Bluing is available Luther Ford Products Co., P.O. Box 201405, Bloomington, MN, 55420)-
food colors - assorted
blotter paper for tree or lava rock, charcoal briquettes, or coal
bottle to hold crystal solution, 250-mL (8 ounces)
aluminum foil muffin pans or small dishes to hold tree, coal, or briquettes.
stirrer

2. Safety Precautions:

Wear safety goggles or glasses to protect eyes from splashes or fumes.

Ammonia fumes are irritating, particularly to the eyes. Work in an area with good ventilation. Avoid skin contact as ammonia is toxic.

The crystal growing solution should be made up fresh, shortly before use and not stored. The solution decomposes to form cyanides in storage.

3. Disposal:

Liquid materials used in this experiment can be washed down the drain with running water.

4. Experimental Procedure:

Growing a crystal garden

To prepare the crystal growing solution, mix 90 mL (6 tablespoons) water, 90 mL (6 tablespoons) liquid laundry bluing or Prussian blue, 15 mL (1 tablespoon) household ammonia, and 100 grams (6 level tablespoons) sodium chloride, NaCl, in a beaker or suitable container. Stir until the salt is dissolved. The solution can be stored in an air-tight bottle.

For a crystal tree, cut heavy blotter paper into the shape of a tree. Use the design shown in Figure 1, or make up your own. Put drops of food color on the tips of the branches and allow it to dry.

Place the tree in a small, shallow pan or dish, and add one to two tablespoon of the crystal growing solution. Allow the tree to stand undisturbed for several hours or overnight.

For a crystal garden, place a charcoal briquette, lava rock, or water pre-soaked piece of coal in a aluminum foil muffin pan or glass dish. If desired, drops of food color can be put on the briquette, rock or coal and allowed to dry before addition of the crystal growing solution.

Pour some of the crystal growing solution around the briquette, lava rock, or coal. Let this stand in a warm, dry place, where it will not be disturbed. Depending on temperature and humidity conditions, crystals cam begin growing within two hours.

Investigating the effect of different components on crystal growth

Prepare three crystal growing solutions omitting one of the ingredients each time. Attempt to grow a crystal garden following the procedure above.

What results are obtained if laundry bluing is not used in the crystal growing solution?

What results are obtained if ammonia is not used in the crystal growing solution?

What results are obtained if salt is not used in the crystal growing solution?