MAGIC® TREE[1]
An Explanation

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Magic® Tree is a miniature artificial tree that grows forming ornamental "buds" in as little as 15 minutes, and "magically" growing into a delicate tree in about 2 hours.

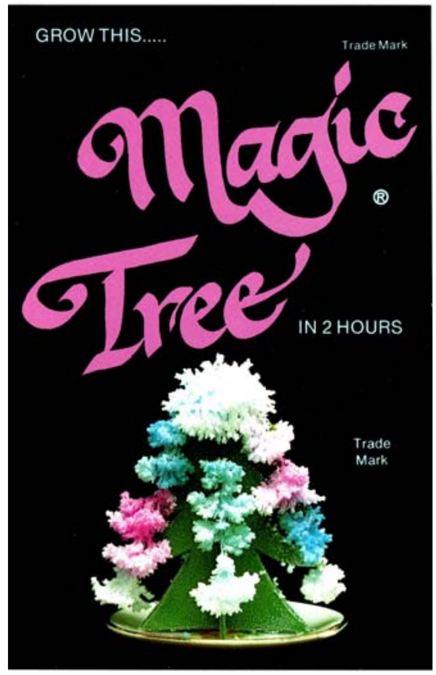

Figure 1. The Magic® Tree package

The tree is composed of two pieces of white or green colored blotter paper with red, yellow, green, and blue colored tips on the branches. (See Figure 2) The colors are dyes consisting mainly of commonly available food colors. The tree is then placed in a small amount of growing solution made from the accompanying blue-green colored powder mixed with 1 teaspoon (5 mL) of water. Over a period of time, small crystals will grow on the ends of the branches. After about 2 hours, the ends of the branches contain clusters of crystals. After all the solution is used up, the tree will dry and, if protected, can last for months.

The blue-green colored powder consists of an alkaline salt, an ammonium salt, and water. A representative solution (but not the exact Magic® Tree formula) can be made from 6 tbsp. sodium chloride (not an alkaline salt), 1 tbsp. ammonia, 6 tbsp. water, and 6 tbsp. liquid laundry bluing (such as Mrs. Stewart's Liquid Bluing[2]). In operation, the solution moves up the tree by capillary action. The tree is permeated by the solution, however, the branch tips, being tapered to a point, experience the most rapid rate of evaporation resulting in crystal formation. (NOTE: tbsp. = tablespoon)

During the growth of the Magic Tree, it is commonly observed that the "buds", or initial crystals, usually form on the second from bottom branches first, rather than the bottom branches. This is probably due to the increased humidity close to the growing solution which would slow the rate of evaporation from the branch tips. This is a similar effect to supplying humidity to house plants by placing them on damp stones or pebbles.

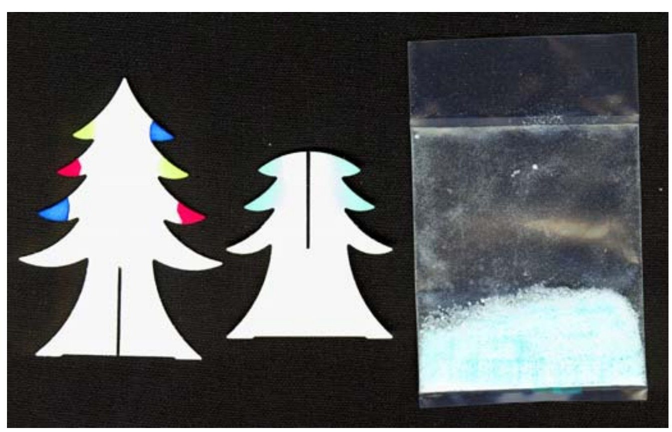

Figure 2. The components of the Magic® Tree

There are several factors that will affect the rate of crystal growth on the Magic Tree. Air drafts will affect the growth of the crystals on the branches of the "tree". The side of the "tree" facing the incoming air will experience a greater rate of evaporation, similar to the effect where water in a puddle will evaporate faster on a windy day. Sunlight will also affect the growth since the heat from the sun, which may be imperceptible to an observer, will cause a rapid rate of evaporation on the side of the "tree" receiving the most light.

The Magic Tree can be reused. If crystals fall off the finished Magic Tree, the experiment can be repeated by dissolving the crystals in a teaspoon of water and placing the tree in the solution. The crystals will regrow on the tree.

As an alternative, the representative solution using sodium chloride, ammonia, water, and laundry bluing can be used to grow crystals on a home-made "tree", a charcoal briquette, or a porous material such as lava rock (such as used in a gas barbecue). To give the crystals some color, drops of food colors can be placed on the growing material and allowed to dry before use.

Figure 3. The Magic® Tree showing three stages of crystal growth.

The chemistry of the Magic® Tree appears to be complex. A laboratory study was made using the mixture of 6 Tbsp. NaCl, 1 Tbsp. ammonia, 6 Tbsp. water, and 6 Tbsp. liquid laundry bluing. In addition to growing these crystals, three trials were done where one chemical was eliminated from each trial to see the effects. If the salt was omitted, no crystals formed. Without ammonia, hard, plate-like crystals, which resembled salt crystals, formed. Without the bluing, only a white crust developed, without any crystals.

Laundry bluing, used to whiten fabrics which have turned yellow or gray, 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:

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

Note: $x = 14\text{-}16$

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 $K[Fe^{II}Fe^{III}(CN)_6]{\cdot}xH_2O$. 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.)

Addition of ammonia, a base, and salt does not change the color of the bluing solution, but the crystals that grow are white. It is suspected that during the evaporation of solvent and resulting crystallization there is probably a reduction of the Prussian blue forming white $K_2Fe^{II}Fe^{II}(CN)_6$ 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. The potassium compound, $K_2Fe^{II}Fe^{II}(CN)_6$, is known as Everitt's salt (first reported by Thomas Everitt is 1835 by boiling potassium ferrocyanide with dilute sulfuric acid).

Since salt crystals grow in a cubic habit and tend to be hard, it is suspected that the fluffy white crystals that form are composed of ammonium chloride and the $KNaFe^{II}Fe^{II}(CN)_6$. The ammonia would form ammonium chloride with the chloride ions from the salt. Ammonium salts tend to form fluffy white (flowering) crystals. (There are two factors that determine crystal formation: (1) the *unit cell* or basic building block that the compound takes and (2) the *habit* or how the unit cells arrange themselves as the crystal grows. (Think of *unit cells* as blocks containing atoms in a specific arrangement and think of the *habit* as the different ways the blocks could be stacked in piles ranging from a cube to a tower to a pyramid. That applies to a single crystal, these are multiple crystals growing together.)

There is a possibility of an air oxidation of the Fe^{II} in the Prussian blue to Fe^{III}. That would form $Fe^{III}Fe^{III}(CN)_6$ which is blue-white in color and contains no counter ions (i.e., no Na^+ or K^+). This is characterized, in the *Handbook of Chemistry and Physics,* as being amorphous (no definite crystal pattern) and seems to be less likely based on the crystals that form in this experiment.

Notes:

[1] Magic Tree is a registered trademark of New Tomorrow, Inc., 7251 Garden Grove Blvd. #E, Garden Grove, CA 92641.

[2]Mrs. Stewart's® Liquid Bluing from Luther Ford Products Co., P.O. Box 201405, Bloomington, MN, 55420 works well for the home-made "tree" experiment.

References:

Sawyer, George M., U.S. Patent 4,196,239, April 1, 1980.

Information on Prussian blue and its structure was found in:

Cotton, F. Albert, and Wilkinson, Geoffrey, *Advanced Inorganic Chemistry*, 5th Ed., Wiley-Interscience, New York, 1988, page 721.

Greenwood, N. N., and Earnshaw, A., *Chemistry of the Elements*, Pergamon Press, Elmsford, N.Y., 1984, page 1271.

Ordering Information:

Magic Trees can be ordered from Flinn Scientific, P.O. Box 219, Batavia, IL 60510.

New Tomorrow, Inc. prefers to sell orders of 50 or more.