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Dry Ice Color Show

Chemical Demonstration

Introduction

Add a small piece of solid carbon dioxide to a colored indicator solution and watch as the solution immediately begins to "boil" and change color.

Concepts

- Sublimation
- Acid–base indicators

Materials

Ammonia, household, 5 mL
Beakers, 1-L, 5
Beakers, 100-mL, 5
Dry ice nuggets, 5 (size of walnuts)
Gloves, insulated type (for handling dry ice)
Water, distilled or deionized (tap water will also work)
Wood splint (optional)

Indicator solutions
Bromcresol green, 0.04% aqueous, 2 mL
Bromthymol blue, 0.04% aqueous, 2 mL
Methyl red, 0.02% aqueous, 2 mL
Phenol red 0.02% aqueous, 2 mL
Universal indicator, 2 mL

Safety Precautions

Dry ice (solid carbon dioxide) is an extremely cold solid (–78.5 °C) and will cause frostbite. Do not touch dry ice to bare skin; always handle with proper gloves. Household ammonia is slightly toxic by ingestion and inhalation; the vapor is irritating, especially to the eyes. Universal indicator solution contains alcohol and is therefore flammable. 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.

Preparation

1. Set five 1-L beakers (or other large transparent containers) in clear view on a demonstration table.
2. Fill each with approximately 750 mL of distilled water (about ¾ full).
3. Add 2 mL of indicator to the water in the beakers, in the following order*:

Beaker (Before)	Indicator (After)	Basic Color	Acidic Color	pH Range
1	Bromcresol green	Blue	Yellow-green	5.4 to 3.8
2	Universal indicator	Purple	Orange	10 to 4
3	Phenol red	Red	Yellow	8.4 to 6.8
4	Methyl red	Yellow	Red	6.2 to 4.4
5	Bromthymol blue	Blue	Yellow	7.6 to 6.0

**The suggested order shown in the table produces a colorful arrangement of solutions, but any order is acceptable.*

Each indicator should begin in the basic range and change to the acidic range upon addition of CO_2 (dry ice). The color changes for each of the indicator solutions from basic to acidic are shown in the table above.

4. To the beakers containing universal indicator and bromthymol blue, add 1 mL of household ammonia.
5. The indicator solutions should now all be in their basic color range. If they are not, add ammonia dropwise to obtain the basic color as indicated in the table above. Avoid adding excess ammonia or the colors will take too long to change when dry ice is added.

6. Set up reference solutions in the five 100-mL beakers by pouring approximately 70 mL from each large beaker into its corresponding small beaker. Set the reference beakers next to their corresponding large beakers.

Procedure

1. Use insulated gloves to add a nugget of dry ice (about the size of a walnut) to each beaker of prepared (basic) indicator solution. The dry ice immediately begins to sublime. Vigorous bubbling occurs and a heavy white vapor appears. Shortly afterwards, each indicator solution changes color to its acidic color (see table above).
2. Have students make observations about the temperature of the solutions and of the vapor. Have students feel the sides of the beakers. Notice that the vapor is cool (rather than hot) to the touch, as are the water solutions. Explain to the students that "boiling" does not always occur at high temperature—a common misconception—and that the solution is not actually boiling. The solution appears to be boiling because there is such a large temperature difference between the water and the dry ice (see *Discussion* section).
3. *Optional:* Take a burning or glowing splint and place it in the vapor. The flame will be extinguished due to the CO_2 gas.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. All materials may be disposed of according to Flinn Suggested Disposal Method #26b. Extra dry ice may be placed in a well-ventilated area and allowed to sublime.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Systems, order, and organization
Evidence, models, and explanation
Constancy, change, and measurement

Content Standards: Grades 5–8

Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12

Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Discussion

When dry ice is placed in water (as in this demonstration), it sublimes rapidly since the water is so much warmer than the dry ice. The solution appears to boil. As the dry ice sublimes to gaseous CO_2, some of the gas bubbles away quickly and some dissolves in the water. A heavy white cloud of condensed water vapor forms above the liquid (due to the coldness of the escaping CO_2 gas). As the CO_2 gas dissolves in the water, the solution becomes more acidic from the production of carbonic acid (H_2CO_3), a weak acid, according to the following equation:

$$H_2O + CO_2 \rightleftarrows H_2CO_3$$

The indicators change to their acidic forms as the pH levels of the solutions drop, producing a color change. The time required for the change to occur depends on the initial pH of the solution, the transition point of the indicator, and how much dry ice was added to the solution.

Acknowledgment

Flinn Scientific would like to thank Lee Marek, chemistry teacher, retired, Naperville North H. S., Naperville, IL for bringing this demonstration to our attention to share with other teachers.

Materials for *Dry Ice Color Show* are available from Flinn Scientific, Inc.

Catalog No.	Description	Catalog No.	Description
AP6201	Dry Ice Color Show—Chemical Demonstration Kit	P0100	Phenol Red Indicator Solution, 0.02%, 100 mL
A0038	Ammonia, Household, 64 oz	V0009	Universal Indicator Solution, 35 mL
B0064	Bromcresol Green Indicator Solution, 0.04%, 100 mL	AP4416	Dry Ice Maker
B0173	Bromthymol Blue Indicator Solution, 0.04%, 100 mL	SE1031	Gloves, Cotton and Canvas
M0159	Methyl Red Indicator Solution, 0.02% aqueous, 20 mL	AP5367	Universal Indicator Overhead Color Chart

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.