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)

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*:

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

*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 CO₂ (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 CO₂ 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 CO₂, 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 CO₂ gas). As the CO₂ gas dissolves in the water, the solution becomes more acidic from the production of carbonic acid (H₂CO₃), a weak acid, according to the following equation:

\[ H₂O + CO₂ ⇌ H₂CO₃ \]

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.

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