Disappearing Ink

Acid–Base Indicators

Introduction

It's magic! It's a mystery! No—it's science. Students write secret messages using a disappearing ink sample and then use chemistry to develop and transmit the messages. This activity allows students to explore the properties of a characteristic acid–base indicator, thymolphthalein, and to extend their understanding of pH and acid–base concepts.

Concepts

- Acids and bases
- pH
- Indicators

Materials

Thymolphthalein indicator solution, 0.04% (alcohol/water solution), 50 mL

Sodium hydroxide solution, NaOH, 0.1 M, 75 mL

Cotton-tipped applicators

Filter paper, chromatography paper, or index cards to test ink samples

Beaker(s), 50- or 100-mL

Glass or plastic demonstration tray

Spray bottle(s)

Safety Precautions

Wear chemical splash goggles at all times. Practice strict hygiene in the use of the chemicals involved in this demonstration. Thymolphthalein solution contains ethyl alcohol and is an alkaline solution (pH 11); moderately toxic by ingestion. Sodium hydroxide solution (0.1 M) is a body tissue irritant. Wear chemical-resistant gloves when handling this solution. Avoid exposure to eyes and skin. Do not allow students to place disappearing ink on their own clothing or on the clothing of others.

Procedure

1. Use a cotton-tipped applicator to "write" a message with the thymolphthalein "disappearing ink" solution on a large piece of chromatography or filter paper or on an index card. The color will fade from blue to colorless almost immediately.
2. Allow the secret message to dry and disappear completely. If necessary, blow on the secret message to make the ink dry and disappear faster.
3. Once the ink has disappeared it can be "developed" (made to reappear) by spraying the message with a mist of 0.1 M NaOH solution from a spray bottle. The blue color will reappear almost instantly and will usually last 3–5 minutes before it fades again.
4. Have students experiment with different solutions to determine the conditions which make the ink color reappear. Some solutions to try include washing soda (sodium carbonate) solution and household (sudsy) ammonia solution. Windex™ or other glass cleaning solutions do not work. Ask the students to estimate the pH range at which the indicator transition takes place.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The disappearing ink and any remaining solutions can be stored for future use or neutralized and flushed down the drain according to Flinn Suggested Disposal Method #10.

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Tips

- Writing and developing disappearing ink messages works best on filter paper or chromatography paper. Some lower-grade filter papers tend to absorb the ink or developing solutions too fast and the resulting message may look more like an ink-blot test rather than a written message. Index cards or plain paper, on the other hand, do not absorb the solutions as well and the solutions tend to simply "run off."
- Set up a special developing area for spraying the sodium hydroxide solution. This can be done over a glass tray or a plastic demonstration-style tray to contain the sprayed mist. Always spray in a direction away from others in the lab. Good housekeeping is important to clean up any residual basic solution from the work area after the demonstration is over.
- If, after repeated use and exposure to air over time, the original disappearing ink solution loses its deep blue color, the color can be restored by the addition of a few drops of the 0.1 M sodium hydroxide solution.
- This is an ideal activity for open-house days in the chemistry lab. Have students prepare filter paper "cards" to hand out to parents and other visitors as they enter the classroom. The visitors can be directed to a special area where volun teers can develop their secret messages—Welcome, Chemistry is pHun, Chemists Love Solutions, ChemMystery, etc. (Volunteers should wear goggles and gloves and should spray in a direction away from all visitors—the hood is a perfect place to set up developing trays.) The student volunteers are able to display their growing chemical knowledge to curious visitors by explaining the chemical basis of the mystery ink phenomenon.

Discussion

Disappearing ink is a mixture of thymolphthalein indicator, ethyl alcohol, sodium hydroxide solution, and water at pH 11. When the blue ink is applied to paper, the blue color quickly vanishes. The disappearance of the blue ink color in air is due to the effect of CO_2, which reacts with moisture in the air to form carbonic acid (H_2CO_3)—the pH change is enough to push the basic form of the indicator (Ind^-) back to its colorless acidic form (HInd).

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$\underset{}{H_2CO_3} + \underset{\textit{blue}}{Ind^-} \rightarrow \underset{\textit{colorless}}{HCO_3^-} + HInd$$

Thymolphthalein is a weak organic acid that behaves as an acid–base indicator in the pH range 9.3 (colorless) to 10.5 (blue). It exists in two different forms—an acid form HInd, which is colorless, and a corresponding conjugate base form Ind^-, which is blue. The color transition range for an acid–base indicator depends on the strength of the weak acid HInd. The color change is due to the changing proportion of the indicator molecules in the acid or base form. When the indicator is in a solution where the H^+ concentration equals the equilibrium constant (K_a) for dissociation of the weak acid HInd, there are almost equal numbers of molecules in the acid form (colorless) and the base form (blue), and the color is pale blue (intermediate between colorless and blue). This pH value is the exact middle of the transition range for the indicator.

$$HInd + H_2O \overset{K_a}{\rightleftharpoons} Ind^- + H_3O^+$$

$$K_a = \frac{[Ind^-][H_3O^+]}{[HInd]}$$

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, chemical reactions.

Answers to Worksheet Discussion Questions

1. Describe what happened in this demonstration. For instance, describe the setup, the chemicals that were used, and any observations you made.

   In this demonstration, a piece of chromatography paper was sprayed with a solution of 0.1 M sodium hydroxide. A blue message that had been written in an invisible ink appeared on the paper and then faded in a few minutes. When you sprayed the paper again, the message reappeared.

2. What causes the ink to disappear?

   Carbon dioxide reacts with moisture in the air to form carbonic acid (H_2CO_3). The carbonic acid caused an acid–base indicator in the ink to turn colorless.

3. What causes the ink to reappear?

   The acid–base indicator in the ink is blue in a base. Therefore, when a basic solution such as sodium hydroxide is applied to the filter paper, the ink turns blue.

4. The indicator in the disappearing ink is thymolphthalein. What color is thymolphthalein in an acidic solution? What color is thymolphthalein in a basic solution?

   Thymolphthalein is colorless in an acidic solution and blue in a basic solution.

Acknowledgments

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Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Disappearing Ink* activity, presented by Lee Marek, is available in *Acid–Base Indicators*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Disappearing Ink* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Disappearing Ink—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP8894	Disappearing Ink—Chemical Demonstration Kit
AP5429	Large Demonstration Tray
AP5338	Spray Mist Dispenser Bottle

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

Disappearing Ink Worksheet

Discussion Questions

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2. What causes the ink to disappear?

3. What causes the ink to reappear?

4. The indicator in the disappearing ink is thymolphthalein. What color is thymolphthalein in an acidic solution? What color is thymolphthalein in a basic solution?