Chemical Additives in Table Salt

Food Additives

Introduction

Color changes help identify the form of iodine in iodized salt.

Concepts

- Chemical reactions
- Consumer chemistry

Materials

Hydrogen peroxide, H_2O_2, 3%, 300 mL

Potassium iodide, KI, 0.1 M, 500 mL

Sodium thiosulfate, NaS_2O_3, 0.1 M, 500 mL

Starch suspension (15 g/liter or 1–2 Eco-foam peanuts/250 mL), 300 mL

Beaker, 400-mL at least

Magnetic stirrer with stir bar (optional) or stirring rod

Spot plate

Morton Iodized Salt container/label (optional handout)

Morton Salt container/label (optional handout)

Stock bottle of iodine (optional handout)

Hand magnifier (optional handout)

Note: Each chemical should also be supplied in a set of Beral pipets marked A, B, C, and D for student testing.

Safety Precautions

Hydrogen peroxide is corrosive to the skin, eyes, and respiratory tract and is a very strong oxidant. Sodium thiosulfate is slightly toxic by ingestion and a body tissue irritant. Avoid contact of all chemicals with eyes and skin. Follow all laboratory safety guidelines. All food-grade items that have been brought into the lab are considered laboratory chemicals and are for lab use only. Do not taste or ingest any food items in the chemical laboratory and do not remove any remaining food items after they have been used in the lab. 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. Remember to wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

1. Without identifying any of the solutions, show students containers with each of the four colorless solutions: 0.1 M potassium iodide, starch solution, 3% hydrogen peroxide, and 0.1 M sodium thiosulfate.
2. Place a stir bar in a 400-mL beaker and then fill the 400-mL beaker about halfway with 0.1 M potassium iodide.
3. While stirring the solution in the beaker, slowly add 3% hydrogen peroxide until the solution turns pale yellow.
4. Continue to stir while slowly adding starch suspension until the solution turns blue.
5. Continue to stir while slowly adding 0.1 M sodium thiosulfate until the solution turns colorless.
6. If conducting student tests, distribute spot plates to each group and give them Beral pipets containing the four "unknown" solutions. Have students duplicate the demonstration and determine the sequence required to get the observed color changes.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. After converting all iodine to iodide using thiosulfate solution (Flinn #12a), flush down drain with excess water.

Tips

- Unlike ordinary paper, which contains starch sizing, no starch sizing is used in the manufacture of currency paper.

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The presence or absence of starch is a useful way to distinguish real currency from counterfeit bills. If the paper contains starch, reaction with a solution of iodine will produce a blue-black color. Real currency will merely show a yellow color—that of the original iodine solution.

A commercial product "Counterfeit Money Detector Pen" is sold at office supply stores and is used by cashiers to spotcounterfeit bills. The formula of the pen is patented, but its reactions indicate that the chemical involved is iodine.

The article, "Iodine Spots the Fake" (*ChemMatters*, February, 2003, page 18) discusses the use of this reaction for detecting counterfeit currency.

- Potassium iodide has a poor shelf life, please act accordingly.

Discussion

The original solution contains iodide which is easily oxidized to iodine, which is yellow in aqueous solution. In this reaction, the hydrogen peroxide is the oxidizing agent.

$$2I^- \rightarrow I_2 + 2e^-$$

$$H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$$

Total: $$2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$$

Addition of starch produces the blue starch–iodine complex. Reaction with thiosulfate ion reduces the iodine to iodide ion, which is colorless in the presence of starch.

$$I_2 + 2e^- \rightarrow 2I^-$$

$$2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2e^-$$

Total: $$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

Note: The above explanation is drawn from the students after making a list of the chemicals (in random order) on the board.

This demonstration serves as an introduction to the student activity, "Chemical Additives in Table Salt," which follows.

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
- Constancy, change, and measurement
- Form and function

Content Standards: Grades 5–8
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science, properties and changes of properties in matter
- Content Standard F: Science in Personal and Social Perspectives, personal health; risks and benefits

Content Standards: Grades 9–12
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions
- Content Standard F: Science in Personal and Social Perspectives, personal and community health

Teacher Note

The "stock bottle" in Question #5 is iodine, which is poisonous.

References

Silberman, R. G., Zipp, A. P. *J. Chem. Educ.*, 1986, *63*, 1098.

Tyler, D. R. *J. Chem. Educ.*, 1985, *62*, 1016.

"The Chemical Adventures of Sherlock Holmes—The Problem of Woolthshrap Prison," *J. Chem. Educ.*, 1995, *72*, 1090

Flinn Scientific—Teaching Chemistry™ E-Learning Video Series

A video of the *Chemical Additives in Table Salt* activity, presented by Kathleen Dombrink, is available in *Food Additives*, part of the Flinn Scientific—Teaching Chemistry E-Learning Video Series.

Materials for *Chemical Additives in Table Salt* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0150	Sodium Tiosulfate Solution, 0.1 M, 500 mL
P0255	Potassium Iodide, 0.1 M, Pkg
H0009	Hydrogen Peroxide, 3z1, 473 mL
S0302	Starch, Spray, 22 oz Can

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

Chemical Additives in Common Table Salt

Aim: To determine the nature and function of some additives in table salt.

1. Examine the labels of the containers of Morton table salt provided and complete the following:

Brand of Salt	**Contents**
Morton Iodized Salt	
Morton Salt	

2. Write the name and the formula of the additive in iodized salt that accounts for the *iodized* term.

3. Write the formula of the negative ion of the additive listed in question #2.

4. (a) Write the balanced equation for the oxidation half-reaction of the above ion. (*Hint:* Recall that the element produced is diatomic.)

   (b) The reaction in (a) occurs in *moist* air. Write the balanced equation for the reduction half-reaction of oxygen to form water. (*Note:* This occurs in acidic solution.)

   (c) Combine the above two half-reactions and write the equation for the total redox reaction.

5. Why would the above reaction be undesirable? (*Hint:* Refer to the stock bottle on the teacher's desk.)

6. (a) The oxidation of iodide ion must be reversed. That is, the iodine must be reduced. Write the half-reaction for the reduction of iodine to iodide ion.

   (b) Examine the container of National Iodized Salt provided on the teacher's desk and list the contents from the label.

   (c) Which additive in this salt is the reducing agent?

(d) Refer to a Table of Ions and write the formula of the negative ion of the reducing agent in 6(c).

(e) Write the balanced equation for the oxidation half-reaction of the ion in 6(d) to form $S_4O_6^{2-}$.

(f) Add the half-reactions from 6(e) and 6(a) and write the total balanced redox equation.

(g) Refer to the list of contents for the iodized Morton salt. Which additive in this brand of iodized salt is the reducing agent?

7. (a) Both iodized and non-iodized salt have a tendency to cake. Sprinkle a few crystals on this paper. Examine the salt crystals with a hand magnifier and describe and/or draw a picture of the salt crystals.

(b) List the additive in the Morton brand of salt which serves as the anti-caking agent.

(c) List the anti-caking agent in the National Iodized Salt.