Testing for Iodide in Table Salt

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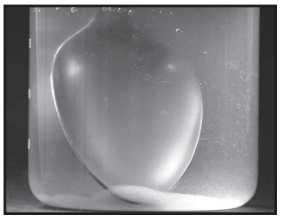
This Activity uses supermarket chemicals to test samples of table salt for the presence of iodine, an essential micronutrient added as iodide ion. The presence of iodide in the salt is made apparent by the appearance of a blue color.

Background

In the test for iodine (see eq 3 in Student Activity), the acid in the reaction is supplied by the addition of white vinegar. A solution of starch is also added to the mixture, so that any iodine produced according to eq 3 forms a blue starch–iodine complex. The blue color may take a few minutes to appear. A weak base is usually present in iodized salt, as the oxidation of iodide to iodine is faster in the presence of acid. Enough white vinegar is used in the Activity to consume any base that may be present in the iodized salt. However, the reducing agent present must be consumed by hydrogen peroxide via eqs 2 and 3 before enough iodine can accumulate to produce the blue color with starch. This can produce a delay in observing the blue starch–iodine color.


Undissolved salt.

The effect of pH on the rate of the reaction may be shown by setting up a mixture with iodized salt in which the vinegar is omitted. The starch–iodine color develops very slowly or not at all, and can require 12–24 hours or more. The effect of added reducing agents upon the rate of the oxidation reaction may be shown by adding 1–2 teaspoons of corn syrup to the iodized salt solution. Corn syrup is primarily a solution of dextrose (glucose) and fructose in water. The starch–iodine color develops more slowly in this case.

Some nations permit the use of potassium iodate (KIO_3) as an iodine supplement in iodized salt. The advantage of potassium iodate over potassium iodide is that the iodate ion is indefinitely stable in air. The procedure used in this Activity will not detect iodine added as potassium iodate. (The U.S. Food and Drug Administration has not approved the use of potassium iodate as a food additive in the U.S.)

Integrating the Activity into Your Curriculum

This Activity can introduce the subject of micronutrients, in terms of their importance and how they may be supplied to a population to prevent disease. It can also be used in a discussion of redox chemistry or the descriptive chemistry of iodine, particularly the facile oxidation of iodide to iodine and the formation of the blue starch–iodine complex.

About the Activity

The quantity of iodide ion in iodized table salt varies; 0.006% by weight is typical. Students can test various types of table or cooking salts, which may or may not be iodized. The author once found salt marked "iodized" that failed to afford a blue color when tested. Halite (rock salt), used for melting ice in winter, may be tested, but the solution must first be filtered to remove dirt. Rock salt does not contain enough iodide to give a blue color.

Linit brand laundry starch was used. Alternatively, a starch solution can be prepared: stir 5 g (1–2 teaspoons) cornstarch with 30 mL (2 tablespoons) cold water until a uniform thin suspension is formed. Slowly pour this suspension into 500 mL (2 cups) of *vigorously* boiling water while stirring so that the boiling does *not stop*, and then allow to cool before use. A mixture may also be prepared by dissolving one cup of starch-based biodegradable packing peanuts into two cups of water. The disposable cups may be made of transparent plastic or of solid color plastic if the interior of the cup is white. In step 1, use either tincture of iodine or povidone–iodine solution, found in the first aid section of stores. Distilled water is recommended; use of tap water can produce erratic results.

Answers to Questions

1. Plain salt typically contains salt and a small amount of sodium silicoaluminate, silicon dioxide, and/or tricalcium phosphate. NaCl absorbs moisture from the air, so it tends to form hard lumps after exposure to humid air. These added ingredients prevent the salt from caking, allowing it to pour easily.
2. Iodized salt also contains dextrose and potassium iodide. Potassium iodide provides the micronutrient iodide ion. Iodide ion is easily oxidized to iodine by oxygen in the air. Dextrose reduces any iodine back to colorless iodide ion.
3. Hydrogen peroxide oxidizes iodide ion to iodine. An excess is used to overcome reducing agents such as dextrose.
4. The vinegar provides an acid solution to facilitate the oxidation reaction.
5. A person would need to consume about 2.5 g (approx. 1 teaspoon) of iodized salt per day.
6. If the seawater was evaporated completely, the resulting (bad-tasting) salt mixture would contain only 1/30 the amount of iodine in iodized salt. One would need to consume about 30 teaspoons of the salt per day.

References, Additional Related Activities, and Demonstrations

1. Moore, Stanford; Link, Karl Paul. *J. Biol. Chem*. **1940,** *133,* 293–311.
2. Hetzel, Basil S. *J. Nutr.* **2000,** *130,* 493S–495S.
3. Rosenfeld, Louis. Discovery and Early Uses of Iodine. *J. Chem. Educ*. **2000,** *77,* 984–987.

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Iodine is an element that is critical for normal function of the thyroid gland, which is a key regulator of the body's basic metabolic rate. Iodine is a micronutrient, meaning we require only small amounts of it. For example, adults need about 150 micrograms of iodine in the form of iodide ion per day. However, an insufficient supply of iodide via diet and drinking water causes the non-cancerous enlargement of the thyroid gland known as goiter. Prolonged lack of iodide can lead to loss of thyroid function and the birth defect known as cretinism, which has been recognized since the Middle Ages. Iodide ion, in the form of potassium iodide, may be added to table salt to produce "iodized salt" in order to easily provide the population with a sufficient dietary supply of this essential nutrient. One difficulty with this is that iodide ion is easily oxidized to iodine by atmospheric oxygen (eq 1).

$$4H^+(aq) + 4I^-(aq) + O_2(g) \rightarrow 2I_2(aq) + 2H_2O(l) \quad (1)$$

An accumulation of iodine in a box of table salt would result in the salt's becoming yellow to red in color and the development of a very noticeable bad taste. To avoid this problem, a reducing agent, typically dextrose ($C_6H_{12}O_6$), is added to reduce back to colorless iodide ion any iodine that may be formed (eq 2).

$$C_6H_{12}O_6(aq) + I_2(aq) + H_2O(l) \rightarrow C_6H_{12}O_7(aq) + 2HI(aq) \quad (2)$$

In this Activity, you will test various samples of salt to determine whether they contain this essential micronutrient. In the test, hydrogen peroxide reacts with iodide ion present in the salt sample (eq 3).

$$2H^+(aq) + 2I^-(aq) + H_2O_2(aq) \rightarrow I_2(aq) + 2H_2O(l) \quad (3)$$

Starch is also added to the testing mixture, so that any iodine produced will form a blue starch–iodine complex.

Be Safe! Food materials used in the laboratory should not be consumed or used later for cooking.

Try This

You will need: distilled water, iodine antiseptic solution, 3% hydrogen peroxide solution, white vinegar, laundry starch solution, plastic measuring spoons or graduated cylinders, one 10 ounce or larger plastic cup for each sample to be tested, disposable plastic spoons, and different types of salt (see suggestions in step 4).

__1. Place 1/2 cup (120 mL) of water in a 10 ounce or larger plastic cup. Add 1/2 teaspoon (2.5 mL) of starch solution. Add several drops of iodine antiseptic solution and stir well. What do you observe?

__2. Place 4 tablespoons (about 80 grams) of salt in a 10 ounce or larger plastic cup. Add 1 cup (240 mL) of water and stir well for a minute. Not all of the salt will dissolve. However, any iodide present in the salt will dissolve.

__3. Now add 1 tablespoon (15 mL) of white vinegar, 1 tablespoon (15 mL) of 3% hydrogen peroxide, and 1/2 teaspoon (2.5 mL) of starch solution to the mixture. Stir the mixture and then let it stand for a few minutes. Does a color form?

__4. Repeat steps 2 and 3 using different salt samples, for example: plain table salt, table salt labeled as "iodized", pickling salt, rock salt (filter any dirt from the solution first), kosher salt, "lite" salt, and sea salt.

Questions

1. Look at the ingredients list on a container of plain (non-iodized) table salt. What other ingredients are included besides salt? What do these ingredients have to do with the Morton Salt slogan "When it rains, it pours?"
2. Compare the ingredients on a container of plain table salt to the ingredients in iodized table salt. Which ingredients are included only in iodized table salt? What is the purpose of the ingredients found only in iodized salt?
3. What is the purpose of the hydrogen peroxide in the test for iodide?
4. What is the purpose of the vinegar in the test for iodide?
5. Assuming iodized table salt contains 0.006% iodide by mass, how much iodized salt would a person need to consume each day in order to get the recommended 150 micrograms of iodide?
6. Seawater contains ~32 g of total dissolved salts per liter, including about 60 micrograms of iodide. Why is it undesirable to evaporate seawater completely to dryness and use the salt to supply our daily 150 micrograms of iodide?

Information from the World Wide Web *(accessed Jul 2007)*

Morton Salt Company: Food Salt FAQs. *http://www.mortonsalt.com/faqs/food_salt_faq.html*

The Salt Institute: Commercial Questions about Salt. *http://www.saltinstitute.org/4a.html*

Iodized Salt. *http://www.saltinstitute.org/37.html*

Effect of Iodized Salt on the Colour and Taste of Food. *http://www.saltinstitute.org/images/iodized-salt-taste-color.pdf*

Salt & Human Health: Iodine Deficiency. *http://www.saltinstitute.org/rss/health-iodine/index.html*

Iodine Deficiency Disorders. *http://www.saltinstitute.org/images/hetzel-b-section1.pdf*