Benedict's Qualitative Solution

A Qualitative Test for Reducing Sugars

Introduction

Benedict's Qualitative Solution provides a test to determine the presence of reducing sugars. All monosaccharides and some disaccharides are reducing sugars—that is, they contain a free aldehyde or α-hydroxyketone group which is capable of reducing cupric or ferric ions. Sucrose, common table sugar and a disaccharide, is a notable exception in that it is not a reducing sugar.

Concepts

- Reducing sugars
- Oxidation–reduction reactions

Materials

Benedict's Qualitative Solution, 5 mL
Dextrose (glucose), $C_6H_{12}O_6$, 5 g
Food samples
Water, distilled or deionized, 100 mL
Beaker, Pyrex®, 250-mL (or similar size Erlenmeyer flask)
Beral-type pipet
Graduated cylinder, 10-mL
Hot plate
Mortar and pestle
Test tube
Test tube clamp or insulated gloves
Test tube rack

Safety Precautions

Copper(II) sulfate is a skin and respiratory irritant. It is moderately toxic by ingestion and inhalation. Sodium carbonate is a possible skin irritant. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Use insulated gloves or test tube clamps when handling the heated test tubes. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

Dissolve 5 g of dextrose in 100 mL of distilled or deionized water to prepare a 5% dextrose solution.

Procedure

1. Add 5 mL of Benedict's Qualitative Solution and 8 drops of the 5% dextrose solution to a test tube.
2. Heat a beaker of water to boiling or to near boiling.
3. Using insulated gloves or a test tube clamp, place the test tube in the boiling water bath. Note any changes after three or four minutes.
4. A positive Benedict's Qualitative test is indicated by the formation of a brownish-red copper(II) oxide precipitate. The color of the precipitate may actually be red, brown, green, or yellow depending on the amount of sugar present, although red is most commonly observed. A color change alone is not a positive test—a precipitate must also be present. No precipitation at all indicates a negative test.
5. Students can test for reducing sugars in foods. An example of how to prepare a food sample is the following: Place an apple slice in a mortar along with a few milliliters of distilled water. Crush the apple with a pestle and add water until a mashed apple solution is obtained. Follow steps 1–4, substituting 8 drops of the apple solution for the dextrose solution.
6. Students can test for reducing sugars in a variety of foods using this method.

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Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Flush all solutions down the drain with an excess of water according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

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

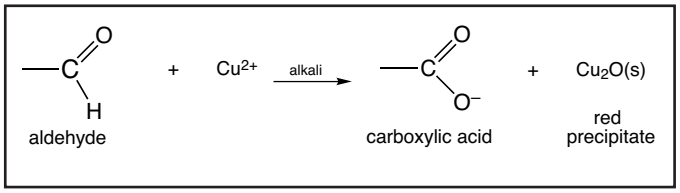
Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Tip

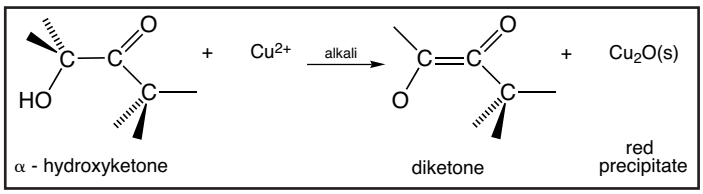
• For effective demonstrations, the volumes of the Benedict's Qualitative Solution and the sugar solution used in the procedure may be scaled up for better visibility.

Discussion

Benedict's Qualitative Solution is used to test for the presence of reducing sugars. A reducing sugar contains a free aldehyde or α-hydroxyketone group which is capable of reducing copper(II) or iron(III) ions. In a reaction with copper(II) or iron(III) ions, the free aldehyde is oxidized to a carboxylic acid (see Equation 1), while the α-hydroxyketone is oxidized to a diketone (see Equation 2). All monosaccharides and some disaccharides are reducing sugars. Examples of reducing sugars include glucose, fructose, galactose, and lactose. Notably, sucrose is not a reducing sugar.



Equation 1



Equation 2

Initially, the copper(II) ions in the Benedict's Qualitative Solution impart a characteristic blue color to the solution. However, when Benedict's Qualitative Solution is added to a solution containing a reducing sugar, the blue copper(II) ions, Cu(II), are reduced to copper(I) ions, Cu(I), by the reducing sugar to form red copper(I) oxide, Cu_2O, which precipitates out of solution. Therefore, the formation of a precipitate indicates a positive test for reducing sugars.

Benedict's Qualitative Solution contains not only copper(II) ions, but also sodium citrate and sodium carbonate. Each component serves a specific purpose. The citrate ions form a complex with the copper(II) ions preventing the copper from precipitating out of solution as copper(II) hydroxide. The sodium carbonate provides a basic environment, which is necessary for the reduction to occur.

References:

Lehninger, A. L.; Nelson, D. L.; Cox, M. M. Principles of Biochemistry; Worth: New York, 1993; pp 298–307.

Campbell, B. N.; Ai, M. M. Organic Chemistry Experiments; Brooks/Cole: Pacific Grove, CA, 1994; pp 409–410.

Materials for *Benedict's Qualitative Solution* are available from Flinn Scientific, Inc.:

Catalog No.	Description
B0015	Benedict's Qualitative Solution, 500 mL
D0002	Dextrose, Anhydrous, 500 g
B0016	Benedict's Qualitative Solution, 1 L
B0171	Benedict's Qualitative Solution, 100 mL
B0172	Benedict's Qualitative Solution, 4 L

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