Sucrose

The Carbon Soufflé

Introduction

Be a chemical gourmet—whip up a carbon soufflé! Your students will be amazed as they watch a yellow solid-liquid mixture turn brown, then black, expand out of the top of the beaker, and solidify. The beaker becomes extremely hot and the odor of burnt sugar will fill the room.

Concepts

- Dehydration reaction
- Exothermic reactions

Materials

Sodium carbonate, Na_2CO_3

Sucrose, $C_{12}H_{22}O_{11}$, 60 g

Sulfuric acid, concentrated, 18 M, H_2SO_4, 60 mL

Balance

Beaker, Pyrex®, 250-mL

Graduated cylinder, 100-mL

Paper towels

Stirring rod, glass

Tongs

Safety Precautions

Sulfuric acid is severely corrosive to eyes, skin, and other tissue; very considerable heat of dilution with water; mixing with water may cause spraying and spattering. Do not handle the carbon product with your hands; use tongs. The carbon product will contain unreacted sulfuric acid. Neutralize acid spills and the carbon product with sodium carbonate. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

The steam produced by the reaction can cause burns. Do not stand over the reaction vessel or inhale the steam produced. The reaction vessel will get extremely hot; allow the vessel to cool before handling. Perform this demonstration only in an efficient fume hood or a well-ventilated room. Wear chemical splash goggles, chemical-resistant apron, and chemical-resistant gloves. Your carbon soufflé is not intended for consumption. It will contain corrosive sulfuric acid.

Procedure

1. All safety precautions must be followed. Perform this experiment only in a fume hood or in a well-ventilated room.
2. Add 60 grams of sucrose to a 250-mL Pyrex beaker.
3. Place the beaker on a layer of paper towels.
4. Using a 100-mL graduated cylinder, carefully measure 60 mL of concentrated sulfuric acid. (Any acid spills should be neutralized with sodium carbonate.)
5. Slowly pour the sulfuric acid into the beaker containing sucrose.
6. Stir briefly with a glass stirring rod. Leave the stirring rod inside the beaker. It will help support the column of carbon produced.
7. Stand back and observe. In a few minutes the solution starts to bubble and expand. Steam will be visible coming out of the mouth of the beaker. The beaker will get hot. Your carbon soufflé reaction takes 15 minutes from addition of the sulfuric acid to the hardening of the "soufflé."
8. Allow the beaker to cool; then follow the cleanup and disposal procedure.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures

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governing the disposal of laboratory waste. When the reaction is complete and the reaction vessel is cool, sprinkle the carbon product with sodium carbonate to help neutralize the remaining acid. Remove the carbon product from the reaction vessel using tongs and thoroughly rinse the carbon product under running water. Place the carbon lump inside a plastic bag. Seal the bag, then place it in the trash.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Tip

- Use the 9-minute period between the addition of the sulfuric acid and the start of the visual reactions to discuss the chemical reaction.

Discussion

Plants combine carbon dioxide and water in the presence of chlorophyll and sunlight to produce food and oxygen. The food is stored energy for the plant and is in the form of sugars or carbohydrates. Sugars have a molecular formula of nC • H_2O: e.g., Sucrose $C_{12}H_{22}O_{11}$, Glucose $C_6H_{12}O_6$, and Arabinose $C_5H_{10}H_5$. This stored energy is released when the food is consumed.

The Carbon Soufflé is a dramatic example of the amount of stored energy in sugar. Concentrated sulfuric acid is a strong dehydrating agent and will literally extract the water from the sugar and leave only carbon (reaction 1). Heat is generated during the dehydration step (–918.9 kJ/mol) and from the dilution of sulfuric acid (–40.6 kJ/mol). Some of the heat is used to convert water into steam.

Reaction 1: $C_{12}H_{22}O_{11}(s) \rightleftarrows 12C(s) + 11H_2O$ (–918.9 kJ/mol)

Reaction 2: $H_2SO_4(l) \rightleftarrows H_2SO_4 \cdot nH_2O$ (–40.6 kJ/mol)

References

Shakhashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers in Chemistry;* University of Wisconsin: Madison, WI; 1983; Vol 1, p 77.

Summerlin, L. R.; Ealy, Jr., J. L. *Chemical Demonstrations: A Source Book for Teachers; American Chemical Society:* Washington DC, 1988; Vol 1. p 62.

Materials for *Sucrose—The Carbon Soufflé* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0134	Sucrose, 500 g
S0283	Sucrose, 2 kg
S0143	Sulfuric Acid, conc., 473 mL
S0052	Sodium Carbonate, 500 g
AP4422	The Carbon Soufflé—Chemical Demonstration Kit

Consult the Flinn Scientific website for current prices.