Flame-Retardant Balloon

A Discrepant Event

Introduction

Show students a "special" balloon that doesn't pop when exposed to a flame. Students will come up with very clever ideas for why the balloon doesn't pop. But, when all is said and done, the "magic" is the result of important scientific principles involving specific heat capacity and heat transfer.

Concepts

- Specific heat capacity
- Heat transfer

Background

Rubber latex begins to melt and decompose at approximately 120 °C. Water boils at 100 °C. When a flame touches a balloon inflated with air, the rubber quickly weakens and the balloon pops. When a flame touches a balloon filled with water, the balloon will not pop. This is because most of the heat energy is transferred into the water instead of the rubber. Water has a large specific heat capacity, meaning it requires a relatively large amount of heat (compared to metals and plastics) to raise the temperature of the water by one degree Celsius. Water has a specific heat of 4.184 J/g·°C, whereas rubber and steel have specific heat capacities of approximately 1.6 J/g·°C, and 0.5 J/g·°C, respectively. The water in the balloon will continue to absorb the heat energy of the flame and the water temperature rises slowly. The temperature of the rubber is prevented from rising any faster than the temperature of the water. Since the temperature of the water will never rise above 100 °C, its boiling point, the temperature of the rubber will not rise above 100 °C until all the water has evaporated. Therefore, the section of the water-filled balloon that is touching the flame will not reach its melting or decomposition temperature, and the balloon does not pop.

Materials

Balloons, medium or large size, opaque, 2
Beaker or graduated cylinder, 50-mL
Candle, match, or butane lighter
Pipet, Beral-type
Water, 25 mL

Safety Precautions

Although latex (in balloons) is considered nonhazardous, not all health aspects of this substance have been thoroughly investigated. Latex may be an allergen. Use caution when handling the candle, match, or butane lighter to pop the balloon. Rubber balloon pieces may turn into projectiles after the balloon pops. Wear chemical splash goggles.

Preparation

1. Measure 25 mL of water using a graduated cylinder or beaker.
2. Use a Beral-type pipet to add the 25 mL of water to one of the opaque balloons.
3. Inflate the other balloon with air until it is approximately the same size as the water filled balloon.
4. Tie off the ends of both balloons.

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Procedure

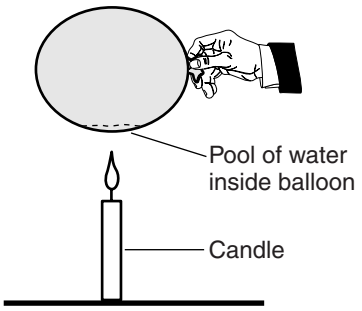

Figure 1.

1. Ignite a candle and place it upright on a tabletop. Or, simply light a butane lighter.
2. Touch the lowest point of the air filled balloon to the flame. The balloon should instantly pop.
3. Relight the candle if necessary.
4. Touch the lowest point of the water filled balloon to the flame. Make sure to touch the lowest point on the balloon to the flame because the water will collect in this region (see Figure 1). The balloon will not pop! *(The rubber will scorch and turn black, however.)*
5. Continue to hold the balloon over the flame for 10–20 seconds. The balloon will not pop.
6. Have students discuss their observations and suggest possible reasons for why the balloon does not pop.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The balloon fragments may be placed in the trash according to Flinn Suggested Disposal Method #26a.

Tips

- Practice this demonstration before performing to determine the best quantity of water to use for different balloon sizes. Also, practice placing the balloon over the flame to make it appear as if the two balloons are identical. Do not make it obvious that you are placing the water-filled balloon over the flame at a "specific" location on the balloon. Students may quickly question whether there is something in the balloon that prevents it from popping.
- Do not use a Bunsen burner or propane burner for this demonstration. The flame will be too large and hot and will quickly pop the balloon containing water.
- Thick, opaque, colored balloons work best because the water inside the balloon will not be visible.

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 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, interactions of energy and matter.

Materials for *Flame Retardant Balloon—A Discrepant Event* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1900	Balloons, Latex, Pkg/20
C0192	Candles, 59 × 1 1/4 9, Pkg/4
AP8960	Butane Safety Lighter
AP1935	Book Matches

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