Pressure Differential Bottle

Introduction

Blow up a balloon and have it stay inflated without tying it. Is it magic? Open up a world of understanding for your students regarding air pressure with this simple, clever device.

Concepts

- Atmospheric pressure
- Force

Materials

Bottle, 1-L PET
Balloon
Cork borer
Stopper/cork (optional)

Safety Precautions

Although the materials used in this demonstration are not considered hazardous, use caution especially when inflating or deflating the balloon. Latex (in balloons) may be an allergen. For proper hygiene, each person demonstrating the pressure differential bottle should use a separate balloon. Wear impact-resistant safety glasses for eye protection. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines.

Preparation

A pressure differential bottle is a regular bottle with a secondary opening (see Figure 1). A pressure differential bottle is also known as a harbottle.

1. Obtain a 1-L PET plastic bottle.
2. Determine the size of the secondary opening (see *Tips* section).
3. Use a cork borer or drill to create the secondary opening on the side of the bottle near the bottom (see Figure 1).

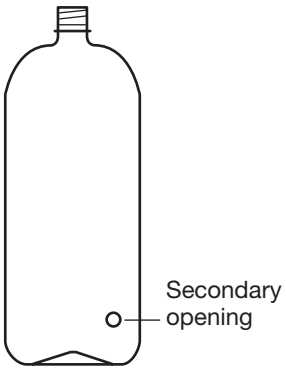

Figure 1.

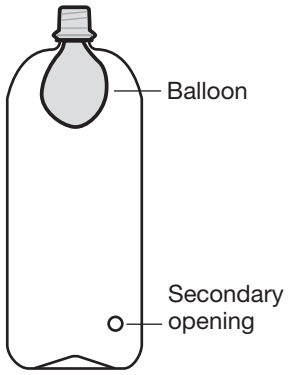

Figure 2.

Procedure

1. Obtain the pressure differential bottle from the *Preparation* step.
2. Place the balloon into the neck of the bottle and stretch the mouth of the balloon over the neck of the bottle (see Figure 2).
3. Blow up the balloon inside the bottle. Once the balloon is inflated, seal the secondary opening with a finger or stopper. The balloon will remain inflated even though the mouth of the balloon is unsealed.
4. Allow air into the secondary opening and the balloon will deflate.
5. *(Optional)* Try to blow up the balloon when the opening is sealed. It can't be done!

Disposal

The pressure differential bottle should be cleaned and then stored for reuse. If using a glass harbottle, store in proper packing materials to prevent breakage. Do not store the balloons inside the bottle. Dispose of used balloons at the end of each demonstration. Store unused balloons for future use.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Publication No. 10996
061616

Disciplinary Core Ideas: Middle School
MS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter
MS-PS2 Motion and Stability: Forces and Interactions
PS2.A: Forces and Motion
MS-ESS2 Earth's Systems
ESS2.A: Earth's Materials and Systems
Disciplinary Core Ideas: High School
HS-PS1 Motion and Its Interactions
PS1.A: Structure and Properties of Matter

Science and Engineering Practices
Asking questions and defining problems
Planning and carrying out investigations
Constructing explanations and designing solutions

Crosscutting Concepts
Cause and effect
Stability and change

Tips

- Traditional harbottles, Flinn Catalog No. AP7205, are made of glass and the secondary opening is sealed with a stopper when demonstrating its use. Plastic bottles can be designed to function as the traditional model by adding a secondary opening to the bottle.
- A 1-liter plastic bottle makes an ideal pressure differential bottle. Make the secondary opening on the side near the bottom of the bottle or on the bottom of the bottle. For best results, make the opening at least 0.5 cm in diameter. If sealing with a stopper, match the size of the opening to the mid-stopper diameter. Reference the *Flinn Scientific Catalog/Reference Manual* to coordinate cork borer and stopper/cork sizes. The opening is best made by a drill or a cork borer. A piece of masking tape placed on the bottle when using the drill/cork borer can reduce slippage. *Please note:* The bottom of a plastic bottle is usually thicker than the sides so making the opening on the bottom of the bottle might require more effort.
- When working with the pressure differential bottle a stopper can be used to seal the secondary opening, however, a finger works well for sleight-of-hand "magic."
- As an inquiry activity give students a regular bottle and one with a secondary opening and two balloons. Challenge students to inflate the balloon and have it remain inflated without sealing the mouth of the balloon.
- Air pressure accounts for many principles seen every day such as weather, flight, breathing, vacuums, and pumps. Have students research an everyday air pressure system.

Discussion

Air has mass, takes up space, and exerts pressure, even though it is not seen. So the question remains: when the balloon is blown up inside the bottle containing a secondary opening and the opening is then sealed, why does the balloon stay inflated? Why doesn't the air rush out of the mouth of the balloon?

The balloon expands into the bottle because of a difference in air pressure. When air is blown into the balloon, the air pressure inside the balloon increases and the balloon expands forcing air out of the secondary opening. (If there is no secondary opening or the opening is sealed, it is difficult if not impossible to overcome the air pressure inside the bottle to blow up the balloon. This can be demonstrated.) When the air is pushed out of the pressure differential bottle's secondary opening due to the expanding balloon, the resulting air pressure inside the bottle around the balloon is lowered and is less than atmospheric pressure. If the secondary opening of the bottle is then plugged with a finger or stopper before removing your mouth from the balloon, the air pressure is not allowed to equalize. Therefore, the air pressure in the bottle around the balloon remains lower than the pressure inside the balloon and the balloon stays inflated. When the secondary opening is unplugged, the higher air pressure outside the bottle will push air into the secondary opening to equalize the pressure in the bottle. As the air pressure increases around the balloon, the air inside the balloon is pushed out of the balloon's mouth until the balloon deflates. The air pressure is again equal both inside and outside the deflated balloon.

Materials for *Pressure Differential Bottle* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7205	Harbottle, Glass
AP1900	Balloons, 12″ Round, Latex, 20/pkg
AP7669	Plastic Soda Bottle, 1-L
AP8326	Cork Borer, Set of 6

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