ACS Chemistry for Life®

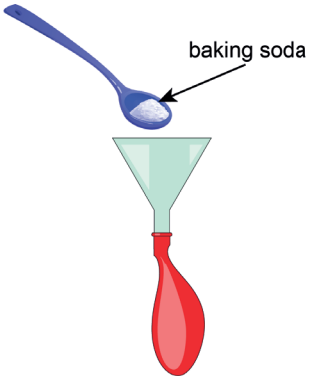
Small group

The Secret Science of Self-Inflating Balloons

Explore the science of self-inflating balloons using the reaction between citric acid and baking soda to generate carbon dioxide. Use the reaction to inflate a latex balloon, extinguish a candle (optional), and inflate a self-inflating balloon.

Question to investigate

How does a self-inflating balloon work?

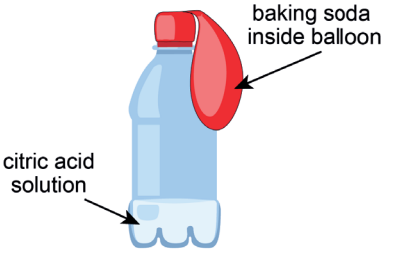


Key chemistry concepts

- Common uses of citric acid and baking soda
- Production of carbon dioxide from reaction of citric acid and baking soda
- Changes in physical properties that indicate chemical reaction
- Use of carbon dioxide to inflate a balloon

Special considerations

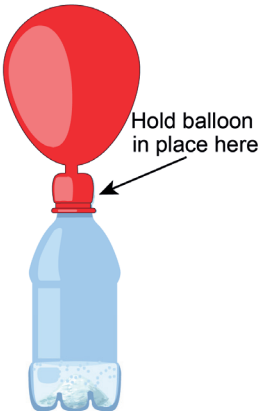
- Self-inflating balloons may squirt, especially if handled roughly.
- Potential hazards include:
  - Acids & bases (citric acid, baking soda)
  - Allergens (latex)
  - Broken glassware
  - Ignition sources (flame)
  - Spills and splashes
- Conduct your own RAMP assessment prior to presenting the activity.



Time required

Preparation:15 minutes

Activity: 15 minutes



Age range

5 -13 years

Group size

Participants work in pairs or trios

One presenter per 2-3 groups

Materials

Per group:

- 1 tsp (5 g) citric acid
- 2 tsp (~22 g) baking soda (sodium bicarbonate)
- 50 mL water
- 2 small cups
- Permanent marker
- 1 round latex balloon
- 1 spoon/spatula
- Funnel, if desired
- 1 flask/bottle with a narrow neck, 8-6 oz or 250 mL
- One self inflating balloon per student + one for the presenter

Flame activity (optional):

- Small candle, such as tealight or votive candle
- Lighter or matches
- Beaker

Additional materials you identified in your RAMP analysis (see "Customize activity," next section)

Prior to the activity

Customize activity to venue

1. Review RAMP safety worksheet for this activity.
2. Revise procedure to adapt to your specific venue and participants.
3. List appropriate procedures for accidents, emergencies:

Identify appropriate safety practices

- Wear appropriate personal protective equipment (e.g., goggles, gloves, etc.)
- Secure loose hair, clothing
- Prohibit eating, drinking
- Clean work area, wash hands after activity
- Additional practices identified in RAMP worksheet:

Prepare materials

1. Prepare 10% citric acid solution: for each group, dissolve citric acid in 50 mL water.
2. Label 2 small cups for each group: label one "citric acid" and the other "baking soda"

Prepare on site

For each group:

1. Pour 50 mL 10% citric acid solution in its labeled cup.
2. Place 2 tsp baking soda in its labeled cup.
3. Arrange the cups, latex balloon, spoon/spatula, funnel (if desired), flask/bottle, and 2-3 self-inflating balloons within easy reach.

For flame demo:

1. Set candle, lighter, and beaker in appropriate location a minimum of 3 m away from participants.
2. Ensure area is free of flammables and fire safety equipment is nearby.

Additional set-up for your venue, audience:

On-site activity

Step	Details	Questions to consider
Demonstrate the self-inflating balloon	• Show participants your self-inflating balloon. • Activate the balloon by breaking the citric acid pouch inside the balloon and shaking it. • As the balloon fills with gas, explain that the participants will be investigating the chemistry that makes this possible.	• What is this? What do you expect to happen? • Why did the balloon inflate?
Combine baking soda and citric acid to inflate a latex balloon	***Direct participants to*** • Pour citric acid solution into the flask/bottle. • Use a funnel, spatula, or spoon to put baking soda inside the balloon. • While keeping the baking soda in the balloon, carefully stretch the neck of the balloon over opening of the flask or bottle. The balloon will look like a floppy hat for the flask or bottle (see illustration). • Holding the neck of the balloon firmly in place, gently lift the balloon to pour the baking soda into the citric acid solution. • Swirl the bottle to combine. Bubbles should form, and the balloon should inflate.	• What do you observe? • Why is the balloon inflating? (See “chemistry details” for explanation)
Demonstrate effect of carbon dioxide on flame	• Light the candle. • Pinch the neck of the balloon from one of the participants’ flask and carefully remove from bottle. Release the contents of the balloon into your beaker. • Pour the gas from the beaker onto the flame of the candle.	• What does a flame need to keep burning? • What stopped the flame from getting the oxygen it needs? • Is carbon dioxide heavier or lighter than air?
Explore the self-inflating balloons	***Direct participants to:*** • Activate their self-inflating balloons. • Younger participants may find it easier to stomp on the balloon over the citric acid packet. Older participants can be told to push on the packet like they are performing CPR	• Why are the balloons inflating? • Where else do you find citric acid and baking soda?
Clean up activity	• Dispose of all solids in the trash. • Pour all remaining liquids down the drain. • Wipe all work surfaces clean with a damp cloth. • Wash hands thoroughly.	

Chemistry details

Adjust these details to match the level of your audience.

The heart of this activity is the reaction of citric acid and baking soda.

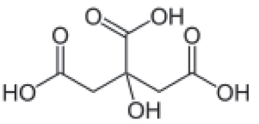
What is citric acid?

Citric acid ($C_6H_8O_7$) is a compound found naturally in citrus fruit and other foods. Like all acids, it is sour, The US Food and Drug Administration categorizes it as "Generally Recognized as Safe," so it is often added to candies and drinks to produce a tart or sour taste. In it's pure form, it is a white powder.

What is baking soda?

Baking soda, also known as sodium bicarbonate ($NaHCO_3$), is a base. Like all carbonates, reacts with acids to produce a salt, water, and carbon dioxide gas when it reacts with an acid.

Baking soda is frequently using in baking. When mixed with acids from vinegar, milk, or juice, it releases CO_2 quickly, giving cake and muffin batters their light texture.



Citric acid, $C_6H_8O_7$

Inside the balloon

When citric acid and baking soda react, they form sodium citrate, carbon dioxide gas, and water (see chemical equation below).

In the latex balloon segment, the CO_2 formed from reacting the citric acid and baking soda fills the balloon.

The self-inflating balloon is made of aluminum-coated polylethyene and contains a pouch of citric acid and loose baking soda. Breaking the pouch allows the citric acid and baking soda to combine. Carbon dioxide is produced, inflating the balloon.

Why did the flame go out?

In the flame segment, the CO_2, from the balloon, is transferred to a beaker. Because CO_2 heavier than air, it pushes the air out of the beaker and fills the beaker. Tipping the beaker over the flame pours the CO_2 out, pushing away the air (and the oxygen in it) and smothering the flame.

$$3NaHCO_{3(s)} + C_6H_8O_{7(aq)} \quad 2Na^{+}_{(aq)} + C_6H_5O_7^{3-}{}_{(aq)} + 3H_2O_{(l)} + 3CO_{2(g)}$$

Sodium bicarbonate | citric acid | sodium ion | citrate ion | water | carbon dioxide

References

American Chemical Society, 2023
ACS Student Chapter at Barry University