

Unleashing Carbon Dioxide

Guide participants through an exploration of how gases dissolve in water, the impact of different surfaces on getting gasses out of solution, and why Mentos has such an explosive effect on soda!

Question to investigate

How does Mentos cause a soda eruption?

Chemistry covered

- **Solubility of gases:** carbon dioxide is a gas that dissolves in water, and its concentration increases with pressure
- **Nucleation sites:** rough surfaces provide sites for gas bubbles to form, so the gas can come out of solution

Special considerations

- Reacting Mentos and soda is exceptionally messy and best conducted outside
- Zero-sugar beverages are best for this activity, as sugar-containing beverages will leave behind a sticky mess
- Potential hazards include:
 - Pressurized containers
 - Spills and splashes
- Conduct your own RAMP assessment prior to presenting this activity.



Time required

Preparation: 15 minutes

Activity: 15 minutes, depending on the number of materials sampled

Age range

7 – 12 years

Group size

- Participants work in pairs or trios
- 1 facilitator per 5 groups

Materials

Per group:

- Single serving colorless carbonated drink, such as club soda or diet lemon-lime soda, unopened
- Non-paper straw, such as plastic, silicone, or metal
- Chenille wire or pipe cleaner
- Clear plastic cup
- 1 roll Mentos candy
- ~100 g sand (there will be some left over)
- ~70 g pebbles (ex. aquarium pebbles)
- Three 2-liter bottles of zero-sugar soda
- Tape
- Markers
- Construction paper
- Scissors
- Index cards

Additional materials identified in your RAMP analysis:

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.
- Other practices identified in RAMP worksheet:

Prepare materials

1. Cut a piece of paper so that its width equals the length of a roll of Mentos.
2. Wrap the paper around the pack of Mentos to make a tube. Use tape to secure the tube.
3. Slide the Mentos down to one end of the tube. Mark how far the Mentos reaches inside the tube. Remove the pack of Mentos from the tube.
4. Repeat until you have 3 tubes

Prepare on site

For each group:

1. For each group, provide a cup, colorless soda, a straw, a chenille wire, and one Mentos candy.
2. In an open, easy-to-clean space, provide each group with 3 bottles of soda, 3 paper tubes, and equal volumes of sand, pebbles, rolls of Mentos, and three index cards.

Additional set-up for your specific venue and audience:

On-site activity		
Step	Details	Ask participants:
Examine a straw	<p>Note: keep all carbonated beverages sealed until ready for use.</p> <p>Direct participants to:</p> <ul style="list-style-type: none"> • Open the colorless beverage. Tilt the cup and slowly pour the soda down the inside of the cup to make as few bubbles as possible. • Place a straw in the soda and look at the straw from the side. 	<ul style="list-style-type: none"> • Roughly how many bubbles are on the straw? • What are the bubbles? Why are they forming?
Compare the surfaces of a straw and chenille wire	<p>Direct participants to:</p> <ul style="list-style-type: none"> • Place a chenille wire/pipe cleaner the soda • Look from the side to see if bubbles also form on the chenille wire. <p>Explain that carbon dioxide bubbles form wherever there is a nucleation site. Chenille wire has a lot more surface than a plain straw. (See “Chemistry details”)</p>	<ul style="list-style-type: none"> • Which has more bubbles—the straw or the chenille wire? • What else do you think would have the same result as the chenille wire? Why? • What do you think would happen if you did this again with cold soda?
Compare surface of Mentos to straw and chenille wire	<p>Direct participants to:</p> <ul style="list-style-type: none"> • Place 1 Mentos candy in the soda. • Watch the candy from the side to see what happens. 	<ul style="list-style-type: none"> • How do the bubbles on the candy compare to the straw and chenille wire? • What can you conclude about the surface of the candy?
Fill tubes with Mentos, pebbles, sand	<p>Direct participants to:</p> <ul style="list-style-type: none"> • Fill one tube to the mark with unwrapped Mentos. Use index card to hold the contents of the tube in place. • Fill another tube to the mark with pebbles. Use index card to hold the contents of the tube in place. • Fill the third tube to the mark with sand. Use index card to hold the contents of the tube in place. 	<ul style="list-style-type: none"> • What do you think will happen when you add each to the soda? • Which do you think will have the most nucleation sites?

On-site activity		
Step	Details	Ask participants:
Test Mentos, pebbles, sand	<p>Direct participants to:</p> <ul style="list-style-type: none"> • Open one bottle of diet soda and set it on a flat surface. • Put the open end of your tube of Mentos on the index card and place it directly over the opening of the soda bottle. • Remove the card and let all the Mentos, drop into the soda at once and quickly move out of the way. • Repeat with remaining soda, pebbles, and sand 	<ul style="list-style-type: none"> • Which produced the highest fountain—the Mentos, pebbles, or sand? • The fountain experiments used the same volume of Mentos, pebbles, and sand. What would be different if you used the same mass of Mentos, pebbles, and sand? • What happens if you use different types of soda to make the fountain?
Clean up	<ul style="list-style-type: none"> • Dispose of all solids from this activity in the trash. • Dispose of all liquids down the drain. • Clean all work surfaces with water or a damp cloth. • Wash hands thoroughly. 	

Chemistry details

Adjust these details to match the level of your audience.

Gases can dissolve in liquids. For example, fish breathe gaseous O_2 dissolved in water, and the excess CO_2 in the atmosphere is what is currently affecting the acidity of the oceans.

You can determine the amount of gas dissolved in a liquid using Henry's Law:

$$C = kP_{\text{gas}}$$

where

C = the concentration of the gas in solution

k = Henry's Law constant (for a given gas and solvent at a given temperature)

P_{gas} = the partial pressure of the gas above the solution

As Henry's Law shows, the higher the pressure of a gas over a liquid,

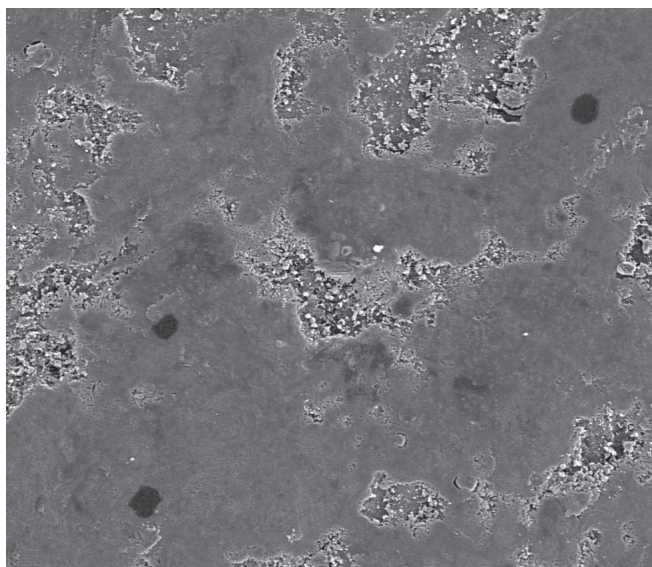
the greater the concentration of that gas in solution.

To create the fizz in soda, the soda solution is super-saturated with CO_2 , then stored under even more CO_2 to keep the gas in solution. When the bottle is opened, the excess gas rushes out. The CO_2 that remains in solution starts collecting on any available bumpysurfaces. The surfaces provide nucleation sites, where the CO_2 molecules collect and form bubbles.

All the items you put in the soda aren't really as smooth as they look with just your eyes. If you could look at the straw, pebbles, and Mentos with a super-strong microscope you would see that they have tiny dents, scratches, and bumps on them. All of

these features create additional surface. So, a straw has some extra surface that you can't see with just your eyes. And the chenille has even more surface than a straw, thanks to its fluffy fibers, which is why it collected more bubbles.

Not only is the surface of the Mentos bumpier than it looks, it develops even more pits and ridges as the sugar in the candy's coating dissolves in the water of the soda. Additionally, that candy coating also contains gum arabic, a stabilizing agent that also reduces the surface tension of the soda, allowing bubbles to escape more easily.



Scanning electron image (SEM) of the surface of a Mentos shows the bumpy surface of the candy.

Photo credit: Wikimedia Commons

References

American Chemical Society, 2023
ACS Student Chapter at Eckerd College

acs.org/OutreachActivities

© 2023 American Chemical Society | Unleashing Carbon Dioxide, p. 5