

Cloud Bubble

This activity is very photogenic and invites participants to explore dry ice in water, in a careful and controlled way. Participants pull a bubble film over the opening of a carafe that contains dry ice, water, spices, and air. The dry ice sublimates, creating large bubbles in the water. When these pop at the surface, more gases are added to the headspace of the carafe. The flexible bubble film is pushed and stretched by these gases to form a bubble dome. Participants can try multiple times to make the largest and longest-lasting bubble that they can make.

Ages	Activity Time	Group Size
5 - 11 years	Preparation: total 45 minutes in advance 15 minutes on-site Activity: 10 minutes	Number of participants 12 participants per hour Ratio of facilitators to participants 1:2

Concepts to Explore

- **Dry ice is the solid form of carbon dioxide**
Dry ice is much colder than water ice.
- **Sublimation**
Sublimation is the process of a solid changing state to become a gas.
- **Aroma is a distinctive and pleasant odor.**
Spices add aroma and taste to food.

Safety Requirements & Other Considerations

- Participants and facilitators must wear safety glasses at a minimum.
- Use caution when handling dry ice. When purchasing dry ice, bring a cooler and thick cotton gloves to handle it in the store.
- If dry ice is transported in a car, be sure to place the cooler in the trunk or back of the car and ensure that the cooler can release gas as the pressure builds. Carbon dioxide may displace oxygen in an enclosed space such as a car, so open the windows slightly to bring in fresh air and ventilate the car. Once you reach your destination, remove the cooler containing dry ice and place it in a well-ventilated area.
- Only the facilitator can handle the dry ice. At -79° C (-110°F), dry ice is very cold and will harm bare skin.
 - Wear protective thick cotton gloves and use silicone (never metal) tongs.
 - Over a deep tray and out of reach of participants, use tongs to transfer a single piece of dry ice to a plastic half-carafe.
- As with all outreach activities, use plastic rather than glass beakers and containers.

Question to Investigate

What is the biggest and longest-lasting bubble you can make?

Materials Required

- 2 dewars or cooler for dry ice
- 2 silicone tongs for handling dry ice
- 4 pairs of thick cotton gloves for facilitators
- 2 kg (approx. 4.4 pounds) dry ice, pellet form
- 2 large bottles w/ red lids for water, 2 L or 2-quart capacity
- 6 sheets of felt, 8 in. x 35 in.
- fabric scissors
- bubble solution
 - dishwashing liquid (avoid extra grease-removing types)
 - glycerin
 - distilled water
 - clean bottle, w/ secure lid for the bubble solution
 - beaker, 1000mL
 - plastic beaker, 90 mL
- 6 plastic beakers, 200 mL
- 2 pitchers for easy pouring
- 6 plastic half-carafes, at a minimum
- 6 narrow shallow trays
- ≥ 100 cinnamon sticks, shorter than 3 inches
- ≈ 25 vanilla pods, cut into quarters
- kitchen scissors to cut vanilla pods
- 8 bowls
- 4 buckets with handles
- labels: 10 water, 1 bubble solution, 6 cinnamon, 6 vanilla
- 6 food service trays
- 4 deep trays
- 12 microfiber cloths

Notes

- While many brands of dishwashing liquid can be used to make a great bubble solution, we have found that regular Dawn® works well.
- Use *regular* liquid dish detergent. Extra grease-cutting dishwashing liquid hinders bubble formation, so avoid these types of formulations.
- Glycerin is sold in some pharmacies, online make-it-yourself skin-care businesses, and science education suppliers

- The plastic half carafe is available through online bar and restaurant suppliers. The narrow neck of the half-carafe prevents participants from touching the dry ice, while the wide opening allows participants to make large bubbles.

Preparation

Prior to Activity

- Make bubble solution.
 - Use the small plastic beaker to measure 30 mL glycerin and 60 mL dishwashing liquid. Pour these liquids into a beaker for mixing.
 - Add 750 mL of distilled water and gently stir until the glycerin dissolves.
 - Pour solution into a clean 1L bottle, secure with the cap, and label the bottle **bubble solution**.
- Use fabric scissors to cut the felt into strips, 4.5 cm x 20.5 cm (1.75 x 8 inches)
- Label 2 pairs of bowls **cinnamon** and **vanilla**.
- Label 2 2-L bottles, 6 small beakers, and 2 large beakers.
- Use kitchen scissors to cut vanilla pods into fourths.
- Place cinnamon sticks and vanilla in separate quart storage bags or reusable containers that seal well.

On-Site

- Arrange three food service trays along the front of each table and 2 deep trays along the back of each table near the facilitators.
- Pour bubble solution into the 4 narrow trays and place 2 along the front of each table between the food service trays.
- Place one half-carafe and one small plastic beaker on each tray.
- Fill the 2-quart bottles with water and then use this water to half-fill the pitchers.
- Pour about 180 mL of water from the pitchers into each of the 6 small clear plastic beakers.
- Place the cinnamon and vanilla pods in their containers. Then give each facilitator one pair of spices.

Facilitation Instructions & Questions

1. Introduce the challenge to make the biggest longest-lasting bubble dome possible.

Instructions

- Invite participants to make cloud bubbles. Tell them that these are made with bubble solution, like normal, but rather than using your breath or moving air to blow them, you will use solid carbon dioxide, aka dry ice, in water.

Questions

- How do you normally blow bubbles?

2. Compare the phase changes of (water) ice to the phase changes of dry ice.

Instructions

- Talk about experiences with ice melting or water evaporating. Then explain that dry ice goes through phase changes, too.
- Dry ice is frozen like water ice. It is called dry ice, because instead of melting the way wet (water) ice does, it changes phase to become a gas. Skipping the liquid phase like this is called **sublimation**.

Questions

- What are the three states of matter you learned about in school?
 - 8- or 9-year-olds will know
 - Children younger than 8 likely have not learned this yet
- Water is a liquid.
 - What happens when water freezes?
 - What happens when water evaporates?

3. Safely transfer one pellet of dry ice from the dewar into the carafe.

Instructions

- Tell participants to pour all the water from their beaker into the carafe.
- Then take the carafe while you warn that dry ice is so cold that it will hurt and damage your skin if you touch it. This is why you are putting on gloves and using tongs to handle the dry ice.
- With the carafe in the deep yellow tray, use tongs to transfer one pellet of dry ice from the dewar into the carafe.
- Return the carafe to the blue tray.

Questions

- How will you stay safe when using dry ice?
- Can you see the bubbles of carbon dioxide and water vapor moving to the surface of the water and popping?

4. Make a bubble dome on the top of the carafe.

Instructions

- Model how to hold and pull a piece of felt through the bubble solution while participants do the same.
- Then show them how to slide the felt across the top of the carafe to make a bubble film.
- Then watch as the bubble dome grows.

Questions

- What do you notice about this bubble and how it forms?



5. Add a cinnamon stick and piece of vanilla to the water.

Instructions

- Tell the participants to drop a cinnamon stick and a piece of vanilla in the carafe with the water and dry ice.
- Explain that cinnamon comes from the inside layer of the bark of a tree and vanilla is a seed pod made after an orchid flower is pollinated.
- The dry ice and water remove molecules from the surface of the spice and release them into the air when the bubble pops.
- The bubble is filled with carbon dioxide, water vapor, and molecules from the spices that our noses can detect.
- Invite participants to make more bubbles over the top of the carafe trying to make the largest that they can.
- Carefully replace the felt strip so that the ends hang over the edge of the narrow tray of bubble solution.

Questions

- Have you ever eaten food made with cinnamon or vanilla?
- What happens when the bubble pops?
The cloud inside falls down around the carafe and then disappears.
- What does the aroma remind you of?

6. Make more bubbles, trying to get the biggest and longest lasting one possible.

Instructions

- Explain that water vapor and carbon dioxide are invisible. But water vapor does an interesting thing when it gets cold enough. It changes state back to liquid water that we can see.
- This liquid water looks different than water in a bathtub or pool. Instead of being all together, the water becomes many tiny drops of water. These drops are so small they float in the air and look like a cloud.
- Invite participants to make more bubbles over the top of the carafe trying to make the largest that they can.
- Carefully replace the felt strip so that the ends hang over the edge of the narrow tray of bubble solution.

Questions

- How is the cloud inside the bubble, like a cloud in the sky?
They both are made of tiny drops of water floating in air

Clean Up

- Dump the water and spices in the carafe into the bucket between participants.
 - If there was too much bubble solution in the water creating suds, use a fresh carafe until you have time to rinse them.
 - One reason to empty the carafe is that the water is too cold to quickly produce a big bubble.
- Retrieve the cinnamon and vanilla. These can be reused a few times before the aroma decreases significantly. You may choose to use fresh cinnamon and vanilla each time and reuse pieces only if you run out of fresh.
- If the felt is too wet on the ends, replace it with a piece of clean felt.
 - Dispose of the used felt strips.
- Refill the beaker with approximately 150 mL of water for the next participant.
- At the end of the event, use any remaining water to rinse the carafes and narrow trays.
- Empty all the water into the dedicated sink inside the building.
- Place all the plastic items and unused felt back in the bin. We will reuse the carafes, trays, beakers, pitchers, and water bottles.
- Do not return wet microfiber towels to the bin. These towels will be collected near the trunks for washing.
- If the plastic tablecloth looks good enough to reuse, fold it carefully and put it on top of the bin.

Explore the Chemistry

The action of dry ice sublimating in water moves carbon dioxide, water vapor, and the volatile compounds from cinnamon and vanilla into the air in the carafe. The bubble film acts like a flexible lid, holding this mix of gases inside and below the bubble. The cloudy appearance inside the bubble is due to the condensation of water vapor. The tiny drops of water suspended in the mix of gases scatters and reflects light, causing the cloudy appearance.

Water vapor is invisible. If you see something cloudy, such as steam from a tea kettle, condensation is occurring and tiny drops of water are being suspended in the surrounding mix of gases, or air. Clouds in the sky, fog that appears some mornings, or the bathroom mirror after someone took a long hot shower are formed similarly. Water vapor condenses as it enters the cooler surrounding air. Because the water drops are small, they remain suspended in air until the molecules gain enough energy to evaporate and change phase becoming invisible water vapor again.

When a cloud bubble bursts, participants will notice that the cloudiness moves down around the carafe. The tiny drops of water in the air get caught up in the bulk flow of carbon dioxide which is denser than the surrounding air. This is why it sinks. Water vapor on its own is less dense than the normal mixture of gases we call air so is more prone to float in air.

I'm not sure exactly why this activity seems to pull so much aroma from cinnamon and vanilla and transfer it into the air. It seems to be stronger than if these same spices were placed in a cup of water or just sitting in open air. Carbon dioxide can be a good solvent for nonpolar compounds. Water can be a good solvent for polar compounds.

The volatile compounds responsible for the aroma of various spices are more often nonpolar than polar. There are a variety of methods to extract these compounds from spices. When cooking, you might sauté the spices in oil, to help extract these compounds so that they mix throughout the food. Chefs call this step, *blooming spices*. It intensifies the aroma and flavor of the spice throughout the food.

There are other methods for extracting the compounds responsible for the aroma and taste of a spice. Vanilla extract is made by soaking a seed pod in alcohol. Chili oil is made by soaking dried chilis in oil. Essential oils sold for aromatherapy or enhancing the smell of your surroundings are often extracted through steam distillation or carbon dioxide under pressure in its liquid form.

References

- [Sublimation Bubbles](#), *Let's Do Chemistry*, 2018 National Informal STEM Education Network