STEM IN THE LAB

innovate. explore. discover.

Idaho National Laboratory

OUR MISSION

INL's K-12 STEM Program works to inspire Idaho's future STEM workforce, impact students, teachers and families by integrating best practices in STEM education, and empower employees to become STEM mentors to transform K-12 STEM into a driver for innovation.

CO2 TO THE RESCUE OVERVIEW

Chemistry is the scientific study of matter, its properties and interactions with other matter and with other energy. Chemists study chemical substances and how they interact with each other. Chemists at the INL work to research innovative, clean energy solutions. One of the projects they are work on involves using Supercritical Carbon Dioxide as an environmental friendly solvent in extraction processes. This is important because it minimizes waste production, is inexpensive, and very effective in recovering metals from liquid or porous solids. INL chemists in supercritical fluid extraction are helping to develop groundbreaking technologies to recover critical elements that are used in numerous clean energy technologies (including nuclear fuel).

Just like Chemists at the INL who work with different chemical reactions every day, in this activity you will be working with chemical reactions. In this activity, a cell phone has been dropped into a lake. Students will need to develop a device that uses a chemical reaction to prevent a phone from sinking.

SCIENCE BEHIND IT

Reactions occur when two or more molecules interact and the molecules change. Bonds between atoms are broken and created to form new molecules.

VOCABULARY

INNOVATIVE: *featuring new methods; advanced and original*

CLEAN ENERGY: *resources like wind and solar power that generate electricity with little or no pollution*

SOLVENT: *able to dissolve other substances*

EXTRACTION: *the action of taking out something, especially using effort or force.*

** Kits can be purchased from the American Chemical Society. Click on the link below to order CO2 to the Rescue Kits:*
https://www.store.acs.org/eweb/ACSTemplatePage.aspx?site=ACS_Store&WebCode=storeItemDetail&parentKey=7cc4fee6-70b1-4a81-b271-cb3c55665f2d

MATERIALS

- *Citric acid*
- *Cream of tartar*
- *Baking soda*
- *Water*
- *Snack size Ziploc Bag*
- *Dropper for detergent*
- *Graduated cylinder (50 ml or 100 ml)*
- *Measuring spoons (⅛ tsp, ¼ tsp, and ½ tsp)*
- *Bucket or large plastic container*
- *2 small plastic cups*
- *Liquid dish detergent*
- *2 Wide clear plastic cups (bowls will also work)*
- *Clay model of a cell phone (12 cm long x 6 cm wide x 1 cm thick - each clay model phone will be about 1 ¼ standard bars of clay)*
- *1 Piece of tape (about 25–30 cm)*

RESEARCH AND DESIGN PROCESS

RESEARCH QUESTIONS

- *Which material produces more gas when it reacts with baking soda?*
- *What happens when water is added to each of the materials?*
- *What are some factors that might prevent the device from being successful?*
- *If you think about a cell phone floatation device, what basic features do you think the device needs to have?*
- *Which acid produces more gas when it reacts with baking soda?*
- *How full will a bag inflate when citric acid, baking soda, and water are combined in a sealed plastic bag?*

PROCEDURES

Ask students how many times have they been to a river, a pool, or a lake and forgotten to take their cell phone out of their pocket before jumping into the water. Have they ever gone to take a picture with their cell phone and had their phone knocked out of their hand straight into the water? Wouldn't it be convenient if there was a device that we could attach to our cell phones so when this happened, the phone would just float? Divide into groups. Each group will test to see which material produces the most foam:

1. *Pour 10 mL of water into each of two small clear plastic cups.*
2. *Add ¼ teaspoon of citric acid to one cup. Label this cup "citric acid".*
3. *Add ¼ teaspoon of cream of tartar to the other cup. Label this cup "cream of tartar".*
4. *Carefully swirl each cup until the powder dissolves as much as possible. (The cream of tartar will not dissolve completely and the resulting solution will look milky white.)*
5. *Add 1 drop of detergent solution to each cup and swirl to mix.*
6. *Add ¼ teaspoon of baking soda to the graduated cylinder and stand the cylinder upright in a wide, clear plastic cup (or bowl).*
7. *Pour the cream of tartar solution into the graduated cylinder with the baking soda. Observe and record the amount (level) of foam in the graduated cylinder. (Expected results: The foam will rise to about the top of a 50-mL graduated cylinder.)*
8. *Rinse out the graduated cylinder, dry it with a paper towel, and add ¼ teaspoon of baking soda to the cylinder. Stand the graduated cylinder upright in a wide, clear plastic cup (bowl).*

9. *Carefully pour the citric acid solution into the graduated cylinder containing the baking soda. Observe and record the amount (level) of foam in the graduated cylinder. (Expected results: The foam will rise faster and higher with the citric acid solution than it did with the cream of tartar solution. The foam may overflow a 50-mL size graduated cylinder).*

Ask the students:
- *Which acid produces more gas when it reacts with baking soda? (Citric acid produces more gas when it reacts with baking soda.)*
- *Which acid should we use in our cell phone rescuing device? Why? (We should use citric acid because it reacts faster than cream of tartar and produces more gas.)*

10. *Have students mix citric acid, baking soda, and water in a plastic bag to see how much it inflates. (Remind students that 10 mL of water, ¼ teaspoon of citric acid, and ¼ teaspoon of baking soda created a lot of foam in the graduated cylinder.)*

PROCEDURE FOR 'DEVICE'

1. *Open a snack-size, zip-closing plastic bag. Work with a partner to add ¼ teaspoon of citric acid to one corner of the bag.*
2. *Add ¼ teaspoon of baking soda to the same corner of the bag. Using your fingers, gently knead or rub the outside of the bag to mix the powders together.*
3. *Use your fingers to hold or close off the corner of the bag containing the powder to keep the solids separate from the rest of the bag. Have your partner carefully add 10 mL of water to the other corner of the bag. Try to prevent the water from touching the powders in the other corner.*
4. *Get as much air out of the bag as you can and seal the bag securely. Let go of the twisted area and tilt the bag back and forth so that the water and the powders mix.*
5. *Lay the bag on a table and see how much gas is produced and how much the bag expands. (Expected results: Gas should be produced and fill up the bag almost all the way.) Use the inflated bag to see if it can make a clay cell phone float.*

PROCEDURE TO TEST FLOATING ABILITY

1. *Make a clay cell phone (12 cm long x 6 cm wide x 1 cm thick). The density of the clay model is very similar to the actual density of the real iPhone.*
2. *Attach the bag to the clay model by wrapping a piece of tape (25-30 cm long) around the bag and clay.*
3. *Place the taped bag and clay in a bucket or large container of water. Expected results: The bag floats with the clay phone just under the surface of the water.*

EXTENSIONS

- *Look at videos of an actual flotation device and discuss and draw how some features from this product might be incorporated into a cell phone flotation device.*
- *Add more to the design of the cell phone rescue device. Draw the device and include captions to describe the special features of their device.*
- *Discuss with other groups, draw, and explain how the flotation device might be activated when it hits the water.*
- *Test smaller amounts of ingredients to see if they will still make the cellphone float.*

RESOURCES

https://public.inl.gov/STEMHelpWanted/Brochure/index.aspx?page=4
https://www.energy.gov/supercritical-co2-tech-team