ACS Chemistry for Life®

Small group

# Nature of dyes

Teach the impact of acids and bases on a common natural dyes made from dried cochineal bugs!

## Question to investigate

How can you make dye from bugs?

## Chemistry covered

- ***Natural vs. synthetic compounds:*** chemicals can be synthesized in a lab or found in nature
- ***Pigments:*** cochineal bugs contain carminic acid, a common natural dye.
- ***Indicators:*** carminic acid is an acid-base indicator that turns from orange-red to burgandy or purple in basic solution

## Special considerations

- Protect work surfaces from staining or work outside
- Potential hazards include:
  - Acids and bases
  - Flammables
  - Spills and splashes
- Conduct your own RAMP assessment prior to presenting this activity.

## Time required

**Preparation:** 5 minutes

**Activity:** 5 – 20 minutes (hands-on), 30 – 60 minutes (total)

## Age range

5 – 13 years

## Group size

- Particaipants work in pairs or trios
- **Younger participants:** 1 facilitator per two groups
- **Older participants:** 1 facilitator per 5 groups

# Materials

***For group***

- Metal spoon and bowl, mortar and pestle, or other materials to crush cochineal bugs
- 7 small cups or beakers
- Markers for labeling cups or beakers
- Disposable dropper pipets or medicine droppers
- Thick paper (e.g. cardstock, watercolor paper)
- 2-3 paint brushes
- 0.5 cup water
- ~1 tablespoon vinegar
- ~0.5 teaspoon baking soda or sodium carbonate
- 2 pieces dried cochineal bugs (Available on Amazon or natural craft supply stores)
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***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. Collect materials
2. For each group, label 2 cups “water,” another 2 “vinegar,” another 2 “baking soda” (or "sodium carbonate"), and the final one “rinse.”

# Prepare on site

***For each group:***

1. Place the vinegar in one of the vinegar cups; set an empty vinegar cup next to it.
2. Mix baking soda and 1 tsp water in one of the baking soda cups; set an empty baking soda cup next to it.
3. Place ~1 tablespoon water in one of the water cups; set an empty water cup next to it.
4. Place the remainder of the water in the “rinse” cup.
5. Arrange the bowl and spoon (or mortar and pestle), paper, paintbrushes, and dried cochineal bugs near the cups.

***Additional set-up for your specific venue and audience:***

## On-site activity

| Step | Details | Ask participants: |
|---|---|---|
| **Introduce activity** | ***Explain:***<br>• Chemicals can be either man-made or found in nature.<br>• Participants will create their own color-changing dye using a natural source (bugs!) | • Where do you see dyes used? |
| **Prepare the dye** | ***Direct participants to:***<br>• Crush the bug into a fine powder using the pestle (or the back of a metal spoon).<br>• Add several drops of water to the mortar (or bowl) and mix the solution using the pestle (or spoon) to make a slurry. | • What does the powder look like?<br>• What color is the slurry? |
| **Change the color of the dye** | ***Direct participants to:***<br>• Transfer equal amounts of slurry to the empty cups labeled “water,” “vinegar,”and “baking soda”. Use a pipet/dropper to add 1-2 drops of water to the cochineal slurry in the “water” cup.<br>• Use a separate pipet/dropper to add 1-2 drops of vinegar to the slurry in the “vinegar” cup.<br>• Use a separate pipet/dropper to add 1-2 drops of baking soda to slurry in the “baking soda” cup. | • What happens when you mix the slurry with vinegar? With baking soda?<br>• Is the change more dramatic if you add more vinegar?<br>• Why do you think the slurry changes to one color for vinegar and another for baking soda? |
| **Use dye to paint a picture** | Explain how the bugs contain carminic acid, its acid/base indicator properties, and its use as a dye. (See Chemistry Details)<br>***Direct participants to:***<br>• Use the slurries, paintbrushes, and paper to paint your own picture. | • How else can you use the slurries? What happens if you soak pieces of fabric, like cotton, wool, or polyester, in them?<br>• What other acids or bases could you use (lemon juice, carbonated soft drinks, cream of tartar, window cleaner)? |

## On-site activity

| Step | Details | Ask participants: |
|---|---|---|
| **Clean up** | • Dispose of all solids from this activity in the trash.<br>• Dispose of all liquids down the drain.<br>• Clean all work surfaces with water or a damp cloth.<br>• Wash hands thoroughly. | |

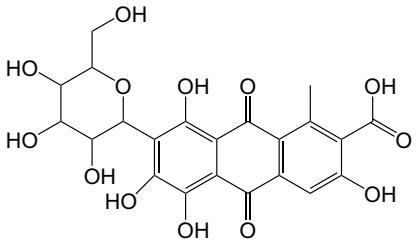
# Chemistry details

***Adjust these details to match the level of your audience.***

You made your own colorful dye out of crushed bugs and water! The cochineal ("koh-chin-eel") bug (*Dactylopius coccus*) is a scale insect that lives on cactuses in the Southwestern United States and South America.

The shell of the female cochineal contains a vibrant red chemical called carminic acid. Carminic acid's color is pH-dependent. For a more orange-red, you can lower the pH (make it more acidic). To create a darker wine red or violet, you need to increase the pH (make it more basic).

Indigenous people in Central and South America, including the Incas and Aztecs, were the first to discover ways to use cochineal bugs to make pigments that could color fabrics and other materials. This dye was once so highly prized that bags of the dried bugs were used as currency or as tribute.




**Molecular structure of carminic acid in neutral solution"**

Spaniards, who colonized these areas, took the cochineal process back to Europe. Cochineal is one of the few natural water-soluble dyes to not degrade with time. Europe had no red dyes that could compare for vividness and endurance, and for a time cochineal was Mexico's second-most valuable export after silver.

Cochineal was used to dye the cloaks of Roman Catholic cardinals and to color jackets that gave British "redcoat" soldiers their nickname.

Today, cochineals are still a natural source of dye for fabrics, make-up, and food products around the world. While generally considered safe, they may trigger allergic reactions in some people, and people with certain dietary restrictions do need to avoid products using cochineals. Additionally, extracting the dye can be expensive and labor-intensive, compared to synthetic dyes.

# References

American Chemical Society, 2023
ACS Student Chapter at North Central College
This activity is a modification of the Nature of Dye activity from the Explore Science: Let's Do Chemistry activity from the NISE Network. (https://www.nisenet.org/catalog/nature-dye)