Glow in the Dark

Recommended Grade Level(s):

Appropriate for: Middle school and High school

Time Requirements:

Activity Time: 30 minutes

Teaching Topics & Concepts:

- Chemiluminescence
- Properties and changes of properties in matter, transfer of energy
- Observation skills

Background:

Chemiluminescent reactions produce light without heat. Students are familiar with chemiluminescent reactions that occur in living organisms, like fireflies, jellyfish, bacteria, and algae—these organisms demonstrate bioluminescence reactions. Forensic scientists use luminol to detect blood—usually used as a last resort because it can damage DNA evidence in blood. Crime lab investigators can spray a luminol solution, and in the dark, the bloodstains will glow with blue light. Hemoglobin (found in our red blood cells) contains iron, which reacts with the luminol like the copper in this demonstration.

Materials:

- Sodium carbonate 10-hydrate, $Na_2CO_3 \cdot 10H_2O$
- Sodium bicarbonate, $NaHCO_3$
- Luminol (3-aminophthalhydrazide)
- Ammonium carbonate monohydrate, $(NH_4)_2CO_3$
- Copper(II) sulfate 5-hydrate, $CuSO_4\ 5H_2O$
- (2) 1-L Erlenmeyer flasks
- (2) 400-mL glass beakers
- 100-mL graduated cylinder
- Electronic balance
- Deionized water

Safety

- Read the SDS sheets for all chemicals before using them.
- Wear safety glasses and gloves.
- Have someone remain by the light switch, so no one has to move while the lights are dimmed.

Procedure:

1. Add 500 mL of deionized water to a 1-L Erlenmeyer flask labeled "Solution A."
2. Add 10.7g of sodium carbonate to Solution A. Stir.
3. Add 0.2g of luminol to Solution A. Stir.
4. Add 24.0g of sodium bicarbonate to Solution A. Stir.
5. Add 0.5g of ammonium carbonate to Solution A. Stir.
6. Add 0.4g of copper sulfate to Solution a. Stir.
7. Add deionized water to solution A flask to a final volume of 1 L.
8. Add 950 mL of deionized water to a 1-L Erlenmeyer flask labeled "Solution B."
9. Add 50 mL of deionized water to a 1-L Erlenmeyer flask abled "Solution B."
10. Pour equal volumes (~100 mL) of Solution A and B into separate beakers.
11. Dim the lights and then mix the solutions in the two beakers together.

Expected Results:

Demonstrates how a chemical reaction can produce luminescence via the release of energy. Upon mixing, the resulting solution glows for several minutes. This demonstration's reaction is an oxidation-reduction reaction in which a photon of light is released from an excited molecule. In the reaction, luminol is oxidized, and its electrons are elevated to an excited state. When the electrons return to the ground state, visible light is emitted.

Follow up:

- The two solutions can be poured simultaneously down a clear spiral plastic tube for a more dramatic effect.
- Experiment with glow sticks—they use the same reaction. Does temperature affect how long they glow?

Teaching notes:

- This demonstration can be enhanced if it is set up so the students can see the mixture through spiraling clear plastic tubing. Spiraling tubing gives a large surface area for light to be emitted and provides a flowing effect and luminescence, increasing the wow factor for your class.
- You can also display the luminol's luminescence is by placing the two solutions in spray bottles, spraying them to create a luminescent cloud. The spray bottles used must make a very fine mist. **Caution:** Don't spray the solutions toward anyone or in a way that can be easily inhaled.
- Use only distilled or deionized water when preparing the solutions. Hard water and softened water contain high concentrations of ions (such as chloride ions) that may interfere with the luminol's excited state and prevent chemiluminescence.

Questions and observations for students:

1. In chemiluminescence, a molecule in an "excited" state (i.e., electrons are at a high energy level) is produced. The electrons in the molecule then must return to their stable state (i.e., lower energy level. Explain how this is linked to the production of light.
2. Why does the light fade after a short time?
3. Give an example of chemiluminescence found in nature.
4. How does chemiluminescence differ from photoluminescence, electroluminescence, and chemiluminescence?

Disposal/Clean-Up:

- The resulting solution can be placed in the science department's organic waste container for proper disposal by a licensed disposal company.