Invisible Gas, Invisible Ink

Overview:

Scientists use ultraviolet light to detect the amount of sulfur dioxide in volcanic gases. In this activity, students model ultraviolet detection strategies by investigating "invisible inks" that glow under an ultraviolet-emitting light.

Objectives:

The student will:

- observe how ultraviolet light can be used to detect colorless substances;
- conduct an investigation to see which substance creates the best invisible ink under ultraviolet light; and
- explain how the absorption of ultraviolet light leads to the fluorescence of substances.

Materials:

- Hand-held black light
- Tonic water (must contain quinine)
- Bubbly, clear soft drink to compare to tonic water
- Cotton swabs
- Toothpicks
- Vinegar
- Liquid laundry detergent with whiteners
- Vitamin B-12 tablets
- White paper
- Clear plastic cups
- Permanent marker
- Student Worksheet: "Invisible Ink"

Answers to Student Worksheet:

Data:

Answers will vary

Analysis of Data:

1. Answers will vary
2. Answers will vary

Conclusion:

1. Answers will vary
2. Answer will vary, but process of testing and evidence of ink quality should be described.

Further Questions:

1. The substances glow because ultraviolet is absorbed, causing visible light (fluorescence) to be emitted.

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Activity Procedure:

1. Show students two liquids, each in a clear plastic cup: tonic water and a clear soft drink. Ask students if they can tell the difference between the two substances using vision alone.
2. Shine a black light on the two substances. Tell students that the black light emits ultraviolet light. The surface of the tonic water should glow blue, while the other liquid will not. Ask students if they know why the tonic water glowed under the ultraviolet light (substances within the tonic water absorb ultraviolet and emit photons of fluorescent visible light).
3. Remind students that ultraviolet light is part of the electromagnetic spectrum. Its wavelength falls just beyond the violet end of the visible light spectrum, so it cannot be seen like visible light can. Remind students that light energy travels as a wave—the wave energy was absorbed by the tonic water in the demonstration.
4. Explain that scientists detect colorless gases from volcanoes in much the same way as the tonic water demonstration. Sulfur dioxide is normally not visible, but it absorbs ultraviolet light. When a substance absorbs ultraviolet light, it emits light at a different wavelength, which can be detected as fluorescence with certain equipment (including black lights). Scientists take advantage of this property to detect the concentration of sulfur dioxide in a sample.
5. If desired, direct the students to collect samples of substances from home (be sure to specify non-toxic substances) that they think might glow under ultraviolet light and bring them in the next day. These substances can be tested along with the others listed in the Student Worksheet: "Invisible Ink." If it is desirable to complete the lesson in one day, skip this step and go directly to step 6.
6. Distribute the Student Worksheet: "Invisible Ink." Explain that many substances can absorb ultraviolet light and emit visible light. Students will investigate different substances to see which one makes the most effective invisible ink.

Note: Vitamin B-12 dissolved in vinegar glows under ultraviolet light, but vinegar alone glows, as well. Students may want to explore different combinations of materials.

Extension Ideas: (1) Exposure to parts of the ultraviolet spectrum can lead to tanning, sunburn, or even skin cancer. Students could use ultraviolet-detecting Frisbees or beads to investigate the strength of ultraviolet light from the sun. They can modify the effects by applying sunscreen of different SPF to the Frisbees or beads. (2) Petroleum jelly glows strongly under ultraviolet light when applied to hands. Students could don gloves and smear them with petroleum jelly to create "glow in the dark" hands.

Name:_____ **Student Worksheet**

Invisible Ink

Testable Question:

What substance makes the best invisible ink?

Background Information:

Many substances fluoresce, or glow, under ultraviolet light. These substances absorb ultraviolet light and emit light that we can see (fluorescence). Such substances can be used as "invisible ink" or ink that appears under ultraviolet light.

Hypothesis:

What substance makes the best invisible ink?

If exposed to ultraviolet light, then _____ will make the best invisible ink.

Experiment:

Materials:

- Hand-held black light
- White paper
- Tonic water
- Cotton swabs
- Toothpicks
- Vinegar
- Laundry detergent
- Vitamin B-12 tablets
- Clear plastic cups
- Permanent marker
- Substances from home, if assigned

Procedure:

1. Obtain several clear plastic cups. Label each cup with a permanent marker to identify the contents (e.g., laundry detergent, vinegar, etc.)
2. Pour a small amount of each liquid test substance into the labeled cups (vinegar, laundry detergent, and tonic water). The vitamin B-12 will need to be dissolved in order to test it as ink.
3. Dip a cotton swab or toothpick into one substance. Try writing some words on paper, and allow the paper to dry.
4. Once the paper is dry, hold a black light close to the paper, and observe whether or not the substance glows.
5. Record which substance was tested and any observations in the "Data" section of the following page.
6. Repeat this procedure with all of the substances to determine which substance makes the best invisible ink.
7. Think carefully about what features make an invisible ink "good" or "bad." Brightness? Drying time? Others? List these features below in Question 1.
8. If desired, substances can be mixed together in additional cups for testing. Be sure to record which substances were mixed together, as well as any observations made about the substances, in the "Data" section.

Name:_____ **Student Worksheet**

Invisible Ink

Data:

Substance *(or mix of substances)*	**Observations**

Analysis of Data:

1. What features make an invisible ink "good" or "bad"?

   _____

   _____

2. Which ink glowed most brightly under the black light?_____

Conclusion:

1. What was the "best" ink tested? _____

2. How did you come to this conclusion? _____

   _____

   _____

Further Questions:

1. Why do some substances glow under the black light? Explain what is absorbed and what is emitted.

   _____

   _____

