How Bright Is Your Glow Stick? Measure It!

https://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p072/chemistry/measure-brightness-glow-stick
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Experimental Procedure

Building Your Light-Measuring Device

1. Your Electronic Sensors Kit comes with a lot of small parts. Find the photoresistor—it is a small, round part, with a squiggly line on the front and two metal leads, as shown in Figure 2.

Figure 2. A photoresistor.

2. Make your light-measuring device by wrapping the glass jar in aluminum foil and taping a photoresistor in the lid with electrical tape, as shown in Figure 3.
    a. Put on your safety goggles and drill a hole in the center of the jar lid, about 1/4 inch in diameter.
    b. Wrap aluminum foil around the sides of the glass jar so no light gets in and seal all edges securely with black electrical tape.
    c. Bend the leads of the photoresistor sideways and cover them in electrical tape, so they do not bump into each other and create a *short circuit*. Leave a small amount of exposed metal at the ends of the leads, so you can attach alligator clips to them later. If your jar lid is made of metal, also cover the metal lid with electrical tape.
    d. Tape the photoresistor over the hole in the jar top, as shown in Figure 2, so it is facing inside the jar when the lid is closed (the side with the squiggly line should be facing the inside of the jar). Make sure to let the leads of the photoresistor stick out from under the tape, so you can attach alligator clips to them later. **Important:** Do not let the leads of the photoresistor touch the aluminum foil. Make sure to insulate the aluminum foil and the leads with electrical tape; otherwise you will create a short circuit and the resistance of your photoresistor will always read zero.

Figure 3. Preparing your light-measuring device by inserting the photoresistor into the lid of a glass jar (left) and wrapping the jar in aluminum foil (right). Make sure to seal all edges and protect the photoresistor from creating a short circuit

3. Determine the resistance baseline for your measuring device and measure the resistance of the photoresistor for the jar with nothing in it and with the lid on and off.
    a. Set up your measuring device in a room with as few disturbances in lighting as possible. The photoresistor is very sensitive, so variations in sunlight coming through a window on a cloudy day, or even shadows and reflections created as people walk around the room, can all affect the readings if you did not seal your jar properly.
    b. Set up your multimeter to measure the resistance of the photoresistor.
        i. Plug the black multimeter probe into the port labeled COM.
        ii. Plug the red multimeter probe into the port labeled VΩmA.
        iii. Connect the multimeter probes to the leads of the photoresistor using alligator clips. Make sure the metal parts of the alligator clips do not touch the aluminum foil, or this will create a short circuit.
        iv. Set the multimeter dial to measure resistance in the 200 kilo-ohm (kΩ) range.
        v. Turn the power switch ON.
        vi. If this is your first time using a multimeter, see the Science Buddies reference How to Use a Multimeter (http://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-multimeter), particularly the section How do I measure resistance? (http://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-multimeter#qmultimetermeasureresistance) to learn more.
    c. Leave the lid open and expose the photoresistor to the surrounding light. Read the resistance across the photoresistor and record it in your lab notebook.
        i. Note the units of the resistance. A "k" indicates kilo-ohms (kΩ).
        ii. If your multimeter screen displays a "1.", that means the resistance is too high for the dial setting. Turn the dial up to the next highest range (for example, from 200 k to 2000 k) and check again.
    d. Close the jar with the photoresistor lid and read the resistance across the photoresistor again. In the dark, the resistance should be in the mega-ohm range. Remember that you may need to adjust the dial setting to get a measurement. Record the resistance in your lab notebook. *Note*: The light level in the closed, light-protected (aluminum-foil-wrapped) jar should be the same when the jar is in a lighted room or in a dim room. If it changes, that means there is a light leak. Find the problem area and cover the light leak with electrical tape.

Measuring Luminescence

Now your light-measuring device is ready for measuring the light intensity of your glow sticks. To minimize unwanted variations during your experiment, position the glow sticks in the jar the same way for each trial, keep movement of the setup to a minimum, and work with a helper so that you can record your readouts quickly. Feel free to also vary the times given below, if you want to obtain further data.

1. First, you will investigate how the light intensity of the glow-in-the-dark object changes over time.
    a. Set your timer to 15 minutes.
    b. Twist a glow stick or glow bracelet to start the reaction. Make sure to shake it enough so that it glows evenly.
    c. Place the glowing object in the aluminum-foil wrapped jar and place the lid on. Your measurement setup should look like the one shown in Figure 3. Start your timer.

Figure 3. Setup of the light-measuring device for measuring the light intensity of glow-in-the-dark objects.

    d. Record the time and signal strength produced by the light of the glow stick every minute for 15 minutes.
2. Next, you will investigate how temperature affects the light intensity of the glow-in-the-dark object.
    a. Once the 15 minutes are over, open the jar and add cold water to decrease the temperature, as follows:
        i. Prepare a cup of ice cold water by putting a couple of ice cubes in a cup of tap water.
        ii. Open the jar, remove the ice cubes, and fill the jar with the cold water so that the glowing object is fully submerged.
        iii. Carefully close the jar again.
    b. Set your timer to 10 minutes and record the resistance of the glow-in-the-dark object in cold water once the 10 minutes are over.
    c. Next, open the jar and replace the cold water with hot water to increase the temperature, as follows:
        i. Prepare a cup of hot water (approximately 50°C or 112°F) by either taking hot water directly from the tap or by heating some water on the stove.
        ii. Carefully open the jar, pour out the cold water and re-fill the jar with the hot water so that the glowing object is fully submerged.
        iii. Carefully close the jar again.
    d. Set your timer to 10 minutes and record the resistance of the glow-in-the-dark object in hot water once the 10 minutes are over.
3. Repeat steps 1 and 2 two more times with fresh glow sticks of the same color and a new cup of cold and hot water (pour out the old water) until you have clear data showing the following:
    a. How the light signal decays with time.
    b. How temperature affects the light intensity.

Analyzing Your Data

1. Make a data table with the resistance readings over time for each trial.
2. Calculate the average resistance for each time point from all three of your trials. Plot your data showing the time, in minutes, on the x-axis, and the average resistance, in ohms or kOhms, on the y-axis. Your resistance curve should start with a low level at first and then gradually rise to a higher level as the light intensity decays. Remember that the resistance of the photoresistor *increases* with decreasing light intensity. Discuss the shape of the curve. Is it a straight line or something else?
3. Make another data table with the temperature (room temperature, hot, and cold) and the resistance readings, in ohms or kOhms, after 10 minutes for each temperature. Graph your results in a bar graph with the temperature on the x-axis and the resistance on the y-axis. What happened to the resistance when you changed the temperature? How did the light intensity change in a hot compared to a cold environment? From your results, do you think the glow-in-the-dark objects will glow longer in summer or winter?