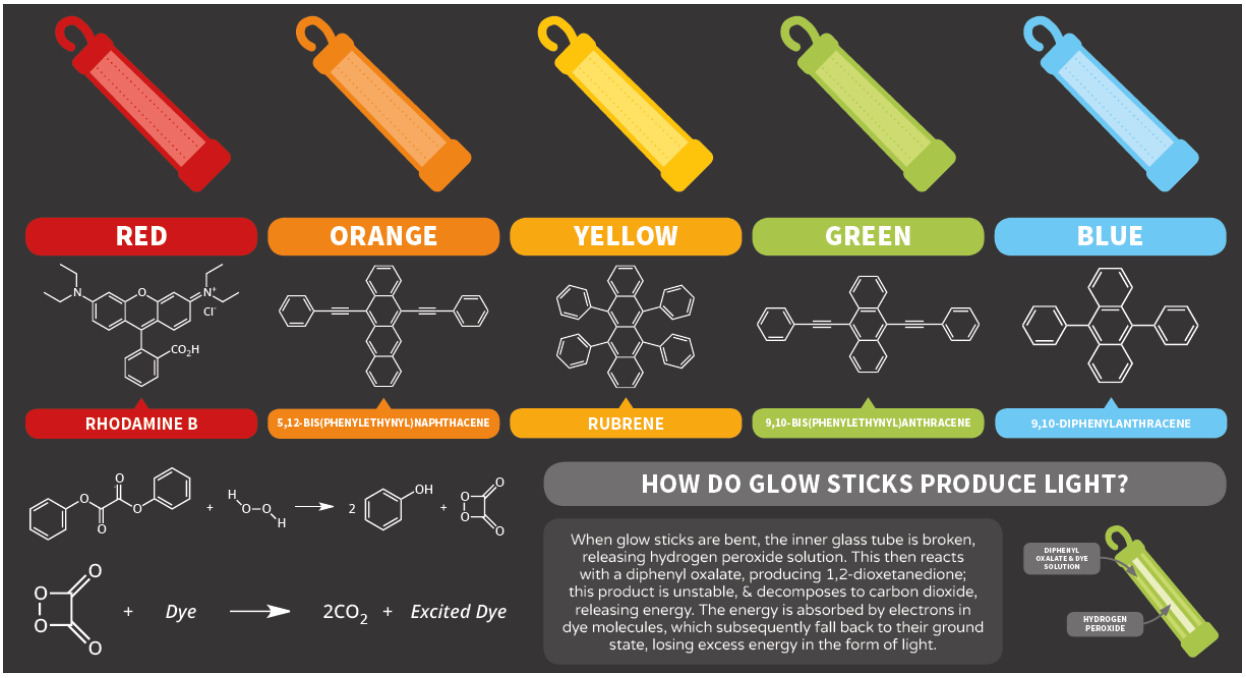
Experiment #4 – Glow Sticks

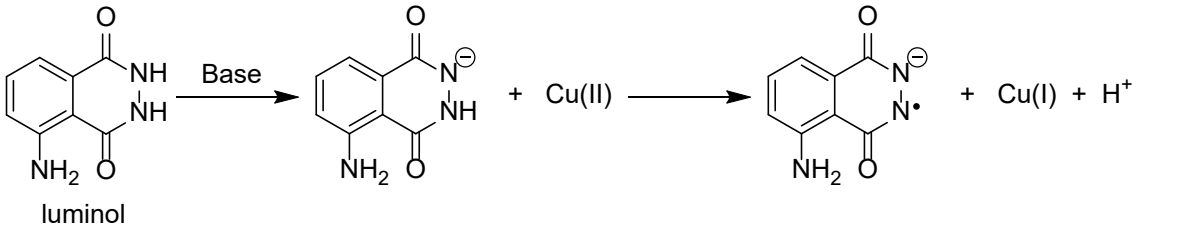
Introduction

Glow sticks have increased in popularity due to their use in recreation, such as for events, camping, outdoor exploration, and concerts, in addition to military and emergency services applications. Glow sticks utilize chemiluminescence (the emission of light from a chemical reaction) to provide light. Glow sticks work by utilizing hydrogen peroxide (H_2O_2), which is stored in a glass capillary in the glow stick, to oxidize diphenyl oxalate. When the capillary is broken by "snapping the glow stick" the hydrogen peroxide is released and mixes with the diphenyl oxalate. As the hydrogen peroxide mixes with the diphenyl oxalate, the diphenyl oxalate is oxidized to 1,2-dioxetanedione, which is a very unstable molecule. The 1,2-dioxetanedione decomposes into two carbon dioxide molecules, releasing energy. If a dye molecule is present, the dye molecule absorbs the energy released from the decomposition of 1,2-dioxetanedione, exciting the dye molecule to a high energy state. As the dye molecule relaxes from the excited state it emits light, resulting in the glow seen from the glow stick. As seen below, different dyes lead to different color glow sticks.

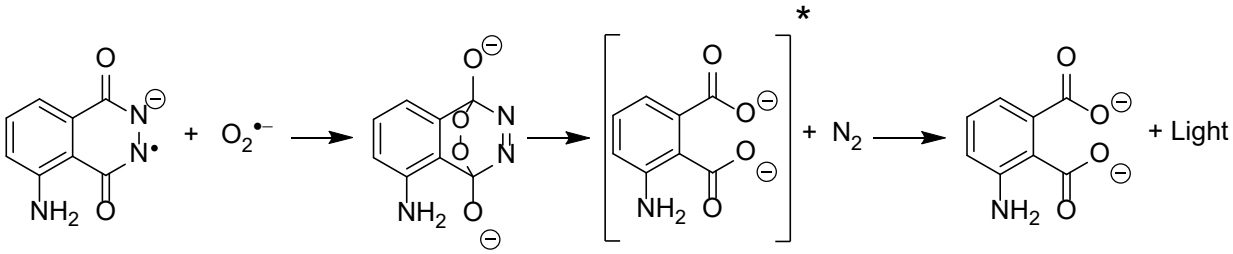


The oxidation of luminol is one of the more well-known examples of chemiluminescence. The first report of chemiluminescence from luminol was reported in 1928 and was used as early as 1934 in a lecture demonstration. The oxidation of luminol is used by forensic scientists to solve crimes. As can be seen in the oxidation mechanism, metal complexes (such as iron in blood) act as a catalyst to produce a blue glow. Luminol mixtures (applied with a spray bottle) used by forensic scientists yield a blue glow for about 30 seconds when they spray encounters trace amounts of blood at a crime scene.

The chemiluminescence of luminol occurs after deprotonation (loss of H^+) of the cyclic nitrogens, and its subsequent oxidation with a free oxygen radical. The oxidation of the luminol creates an excited state, and upon relaxation, a photon is emitted, which is seen as blue light. As you will notice, the reaction needs three things to proceed: a strong base, hydrogen peroxide (to create the free oxygen radical), and a metal compound. The purposes of each starting material will be further explored in the experiment.



luminol



excited state

Procedure:

Solutions

A) 25 mL Hydrogen peroxide in 500 mL water
B) 0.1 g Luminol, 2.0 g sodium carbonate, 0.2 g cupric sulfate, and 0.25 g ammonium carbonate in 500 mL water
C) Water
D) 0.5 g Luminol and 2.0 g sodium carbonate in 1000 mL water
E) 2.0 g Sodium carbonate and 0.25 g ammonium carbonate in 1000 mL water
F) 0.5 g Cupric sulfate in 500 mL water

Start by pouring an equal amount of solution A & B into a scintillation vial (don't overfill it). Be sure to note what you observe and how long the chemiluminescence lasts!

Work on optimizing the chemiluminescence to attempt to get a longer lasting glow stick. (Temperature, amounts of solutions A-F, length of luminescence, etc).

Record below what you tried and how it worked.

Trial #	Amount of Solution A (mL)	Amount of Solution B (mL)	Amount of Solution C (mL)	Amount of Solution D (mL)	Amount of Solution E (mL)	Amount of Solution F (mL)	Length of Glow (seconds)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Notes:

HOW LONG WAS YOUR LONGEST CHEMILUMINESCENCE? _____ seconds or minutes (circle one)

NAME _____ High School _____