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A MULTI-COLORED LUMINESCENCE DEMONSTRATION

by

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Introduction

Chemiluminescence demonstrations are so fascinating to both students and their instructors that it is tempting to describe them as "exocharmic" [1,2]. One of the most popular demonstrations in this category involves oxidation of luminol (3-aminophthalhydrazide) with $Fe(CN)_6^{3-}$ in basic solution [3,4]. The products of this reaction are N_2 and an aminophthalate ion in an electronically excited state, which decays to the ground state by emission of a photon with λ_{max} = 425 nm. Because of the low quantum yield and short emission time of luminol, many people have switched to the H_2O_2 oxidation of lucigenin (bis-N-methylacridinium nitrate) [5]. In their discussion of chemiluminescence demonstrations, Shakhashiri, et al., described the use of a glass-spiral assembly that significantly enhances this demonstration.

While studying possible variations on the lucigenin demonstration [6], we encountered a method of producing a demonstration that gradually turns color from one end of the visible spectrum to the other. By using a clamp to slow down the rate at which liquid flows through the spiral, it is possible to generate almost the entire visible spectrum within the spiral at the same time. Once this has been accomplished, the clamp can be closed and the glow will last for as long as 15 minutes.

Materials

The first step in assembling the apparatus used in this demonstration is to build a glass-spiral assembly [Note 1], such as the one described by Shakhashiri, et al. [4,5]. Attach the glass spiral to a ring stand. Support a glass funnel in an iron ring at the top of the ring stand and connect the stem of the funnel to the top of the glass spiral with Tygon tubing as shown in Figure 1. Attach two iron rings to the ring stand above the glass funnel. Then place two 1-L separatory funnels in the iron rings and position their spouts against the inner wall of the glass funnel. Attach a second piece of Tygon tubing to the bottom of the glass spiral and use a pinch-clamp to partially collapse this tubing. Insert the exit tube of the spiral into a 2-L Erlenmeyer flask, which is used to collect the liquid that flows through the apparatus.

Prepare solutions **A**, **B**, **C** and **D** as described below. Gloves and safety goggles must be worn during both the preparation and handling of these solutions.

Solution A: Dissolve 8.0 g of sodium hydroxide in 650 mL of distilled water. Add 300 mL of ethanol and 50 mL of 30% hydrogen peroxide. Stir until thoroughly mixed. (This solution must be prepared on the day the demonstration is done.)

Solution B: Dissolve 0.2 g of lucigenin [Aldrich: B4,920-3] in 1 L of distilled water. (This solution will keep for several months.)

Solution C: Dissolve 0.5 g of rhodamine B [Aldrich: R95-3] in 1 L of ethanol. Note that rhodamine B is a mutagen and a cancer suspect agent.

Solution D: Dissolve 1 g of fluorescein [Aldrich: 16,630-8] in 1 L of ethanol

Procedure

In their description of the H_2O_2 oxidation of lucigenin demonstration [5], Shakhashiri, et al., proposed two alternate procedures. The first involved mixing solutions **A** and **B** in the glass funnel of the glass-spiral apparatus described above. The second involved adding a fluorescent dye solution, such as solution **C** or **D**, to a beaker containing solution **B,** and then adding solution **A** to this beaker.

We propose a third alternative. Pour 1 L of solutions **A** and **B** into the separatory funnels in Figure 1. Simultaneously open the stopcocks on the two separatory funnels, allowing solutions **A** and **B** to pour into the funnel at the top of the glass-spiral apparatus until the funnel is approximately one-third full. Optimum results are obtained by adjusting the stopcocks so that the funnel remains about one-third full. The rate at which liquid flows through the spiral can also be controlled by opening or closing the pinch-clamp on the exit tube.

If you find that this approach generates air bubbles within the glass spiral, it is possible to start by filling the spiral with ethanol, and then allowing this solvent to flow through the exit tube as the pale-blue luminescent solution flows out of the glass funnel into the top of the spiral.

While solutions **A** and **B** are flowing into the glass funnel, add a small (5-mL) aliquot of solution **C**. The rhodamine B dye in this solution will gradually change the color of the luminescence from pale-blue to red. Once this process has begun, add a small aliquot of solution **D**. The fluorescein dye will now shift the color toward the green end of the spectrum. To shift the color back toward the red end of the spectrum, add a second aliquot of solution **C**. This process can be repeated until the whole spiral is a brilliant blend of colors, at which point you can clamp off the exit tube and freeze the colors for as long as 15 minutes [6].

Caution: If you fill the funnel too full with solutions **A** and **B**, you will reduce the concentration of the dye solution and therefore not achieve good color separa- tion

in the spiral.

References

[1] Ramette, R. W. J. Chem. Ed., 57, 68 (1980).
[2] Bodner, G. M. Chemunity, 11(2), 1-3, 1990.
[3] Alyea, H. N., and Dutton, F. B. Tested Demonstrations in Chemistry. Easton, PA: Journal of Chemical Education, 1965.
[4] Schreiner, R., Testen, M. E., Shakhashiri, B. Z., Dirreen, G. E., and Williams, L. G. "Chemical Demonstrations: A Handbook for Teachers of Chemistry." Volume 1. Madison, WI: University of Wisconsin Press, 1983; p. 156-167.
[5] Schreiner, R., Testen, M. E., Shakhashiri, B. Z., Dirreen, G. E., and Williams, L. G. "Chemical Demonstrations: A Handbook for Teachers of Chemistry." Volume 1. Madison, WI: University of Wisconsin Press, 1983; p. 180-185.
[6] Gundermann, K.-D. and McCapra, F. "Chemiluminescence in Organic Chemistry" Springer-Verlag: Berlin, 1987; p. 196.

NOTES:

1. This demonstration can also be done by replacing the glass spiral with an apparatus constructed by coiling tygon tubing around a plexiglass tube roughly 6 inches in diameter.