JCE DigiDemos: Tested Demonstrations

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Colorful Chemical Fountains

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We have constructed a simple device from plastic champagne cups to provide a novel way of demonstrating the colors of acid–base indicators. The apparatus can also be used to demonstrate chemiluminescence. For younger students, the chemical fountain effectively shows the mixing of primary colors using supermarket food colors.

Materials

Seven plastic champagne cups, with the detachable bases removed

Piece of clear, acrylic tubing, ~26 in. long

Glue, clear-dry caulking, and caulking gun

Block of wood (e.g., pine), ~8 in. × 8 in. × 2 in. with 5/8 in. hole drilled in the center

Teflon tape

Erlenmeyer flask, 500 mL, containing ~500 mL water

Several indicators (e.g., methyl orange, bromothymol blue, methyl red, bromocresol green, universal indicator)

50 mL 0.1 M HCl and 50 mL 0.1M NaOH solutions

Food coloring (red, yellow, blue)

Copper/luminol solution for demonstrating chemiluminescence *(1)*

Construction of Fountain

Seven plastic champagne cups, with the stems removed, are glued equal distances apart along a length of clear acrylic tubing. The top six cups have holes drilled in them so that the solutions drain from one cup to the next and create the fountain effect (Figure 1). The assembly is secured in a wooden base that also serves as a drain to prevent overflow when the bottom cup fills up. The preparation of the chemical fountain apparatus is not difficult and construction can be completed in a couple of hours, but the assembly should be left for several days to allow the glue and caulking to dry completely. The wooden base used to support the apparatus is placed over a beaker to collect the overflow. For appearance and to protect the wood, the wooden base may be painted. Although we examined several designs for the chemical fountain (e.g, gluing the cups together or connecting them with rubber stoppers), we found the arrangement described here works well. Attaching the cups to a sturdy piece of tubing gives the structure rigid support and allows for convenient drainage. Sources for construction materials and detailed instructions for assembling the chemical fountain are provided in the online supplement.

Hazards

Wear safety goggles and rubber gloves when handling hydrochloric acid, sodium hydroxide, and hydrogen peroxide solutions. All three can cause chemical burns. The used solutions should be flushed down the drain with plenty of water. Safety goggles should be worn and care taken when using power tools in the construction of the chemical fountain.

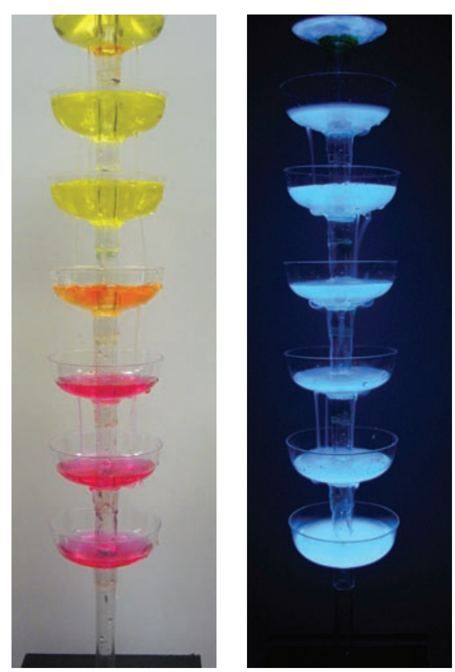

Figure 1. Methyl red fountain (left) and chemiluminescent fountain (right). (A color version of this image can be found on p 1013 of the table of contents.)

Method

Acid–Base Fountain

Place 5–10 drops of indicator in the top cup. Add 5 drops of 0.1 M HCl to the fourth cup. Slowly pour water from the Erlenmeyer flask into the top cup until the bottom cup begins to fill up. When using universal indicator, add 10–15 drops of indicator to the top cup, 5 drops of 0.1 M HCl to the third cup, and 6 drops of 0.1 M NaOH solution to the sixth cup.

Chemiluminescent Fountain

Prepare the copper/luminol solution as previously described *(1)*. Place 2 drops of 30% H_2O_2 into each cup. Dim the room lights and slowly pour the copper/luminol solution into the top cup until the bottom cup begins to fill up.

Food Coloring Fountain

Place 1 drop of the red food coloring in the top cup and 1 drop of blue or yellow food coloring in the fourth cup. Fill the fourth cup first, then quickly fill the top cup. Continue adding water to the top cup until the bottom cup begins to fill. Repeat using other combinations of food colorings.

Discussion

These chemical fountains are simple to perform in a moderate-sized classroom and provide an impressive display for students. It is possible to demonstrate both color ranges of an indicator at once, as well as the intermediate color change. For instance, when methyl red is used, the top cups are yellow indicating methyl red's color at a pH of ~5 or greater while the lower cups turn red on contact with acid. A transitional orange color can be seen as the two colors mix, which represents the indicator color change range. When universal indicator is used, sodium hydroxide solution is also placed in one of the cups to indicate the range of colors (neutral green in the top cup, pink in middle with acid, and blue with base at the bottom).

Chemiluminescence has been demonstrated by a number of procedures reported in the *Journal* (e.g., *1–3*). The chemiluminescent fountain described here is especially impressive, and the effect is clearly visible in the largest of darkened rooms. For younger classes, or if chemical indicators are unavailable, we have also found the chemical fountain effectively demonstrates the mixing of primary colors using supermarket food colorings.

Because a drain is built into the base, the fountain operates cleanly and the contents of the overflow beaker can be washed down the drain. To clean the fountain between demonstrations, fresh water should be flushed through the cups. Any residual liquid remaining in the cups can be removed by tipping the assembly over a large sink.

In time, the caulking used as sealant may stain slightly owing to the indicators. This has little effect on the demonstration, and the caulking can easily be removed and replaced if necessary. In a large classroom, placing a piece of white cardboard behind the acid–base fountain will also improve visibility.

Many modifications to the chemical fountain are possible. For instance, more cups can be added if a longer piece of tubing is used. Ten to twelve stacked cups are especially effective with the chemiluminescence fountain. A small electric aquarium pump (e.g., Via Aqua 80 model submersible pump with variable control) can also be used to recycle the waste water back to the top cup to produce a continuous acid–base fountain. If needed, the tubing attached between the pump and fountain can be lengthened to slow the water flow. A pinch clamp can also be used to control the water circulation. Once the flow of water has been regulated to be constant, drops of acid or base can be added alternatively to the top cup to create a continually changing series of indicator colors. Students quickly learn which colors are associated with each indicator.

Literature Cited

1. Thomas, N. C. *J. Chem. Educ.* **1990,** *67,* 339.
2. Chalmers, J. H., Jr.; Bradbury, M. W.; Fabricant, J. D. *J. Chem. Educ.* **1987,** *64,* 969.
3. Shakhashiri, B. Z.; Williams, L. G.; Dirreen, G. E.; Francis, A. *J. Chem. Educ.* **1981,** *58,* 70.

Supporting *JCE Online* Material

http://www.jce.divched.org/Journal/Issues/2008/Aug/abs1061.html

Abstract and keywords

Full text (PDF)

Links to cited *JCE* articles

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Supplement

Instructions for the chemical fountain assembly

JCE Featured Molecules for August 2008 (see p 1152 for details)

Structures of some of the molecules discussed in this article are available in fully manipulable Jmol format in the *JCE* Digital Library at *http://www.JCE.DivCHED.org/JCEWWW/Features/MonthlyMolecules/2008/Aug/*.

JCE Cover for Jaunary 2005

An alternative chemiluminescent fountain configuration can be seen on the cover of the January 2005 issue of *JCE (http://www.jce.divched.org/Journal/Issues/2005/Jan/cover.html)*.