The Liquid Nitrogen Fountain

ARTICLE *in* JOURNAL OF CHEMICAL EDUCATION · SEPTEMBER 2002

Impact Factor: 1.11 · DOI: 10.1021/ed079p1220

4 AUTHORS, INCLUDING:

Robin Mcrae

Eastern Washington University

13 PUBLICATIONS **219** CITATIONS

SEE PROFILE

Jeffrey Rahn

Eastern Washington University

26 PUBLICATIONS **371** CITATIONS

SEE PROFILE

Tested Demonstrations

edited by
Ed Vitz
Kutztown University
Kutztown, PA 19530

The Liquid Nitrogen Fountain

submitted by: **Robin McRae,* Jeffrey A. Rahn, Timothy W. Beamer, and Norm LeBret**
Department of Chemistry and Biochemistry, Eastern Washington University, Cheney, WA 99004-2440; **rmcrae@ewu.edu*

checked by: **Mark J. Waner and Emily J. S. Brown**
Science Theatre, Abrams Planatarium, Michigan State University, East Lansing, MI 48824-1322

In the course of developing an active traveling chemistry demonstration show, we have encountered the fact, no doubt observed elsewhere, that public-school audiences (particularly those at the middle and elementary levels) are fascinated with demonstrations involving liquid nitrogen. Often, after hour-long shows involving explosions, colored flames, bubbling colored liquids, and clock reactions, we get comments (much to our initial surprise) from students about how cool the liquid nitrogen demonstrations were.

To take advantage of this fascination and in order to promote more interest in science, we have developed the following *Liquid Nitrogen Fountain* demonstration, which we use in conjunction with more standard demonstrations of the properties of this frigid liquid (see ref *1–6* for other demonstrations using liquid nitrogen).

Materials

Plexiglass safety shields
Ring stand with ring
Liquid nitrogen
Balloons
Polyethylene bottle with pop-up drink top
14-gauge and 22-gauge copper wire

Procedure

The demonstration is based on a 500-mL transparent polyethylene bottle, with a screw-on pop-up drink top, of the sort now commonly used for spring water, sports drinks, and soda pop, and which are readily available in supermarkets and quick-stop stores. Liquid dish soap bottles will also work well. Prior to the demonstration, we place a balloon over the popped-up spout of the bottle top and fix it in place by wrapping 22-gauge copper wire around it. The balloons we use are Official Water Grenade Balloons.[1] These balloons are approximately 10-cm × 10-cm × 20-cm when fully inflated, are made of low-density polyethylene, and have a very recognizable grenade-looking design imprinted on them. From extensive testing, we have determined that the reproducible success of this demonstration does depend on the balloons used; it may be necessary to test a few different balloons in order to find a type that works.[1]

At the time of the demonstration, the drink bottle is behind a plexiglass shield and stabilized by placing it inside a ring attached to a ring stand to ensure that the bottle will not tip over. As an added precaution the audience should be at least two meters away from the plexiglass shield. The liquid nitrogen is then poured into the bottle until it overflows slightly. The top, with the balloon affixed, is then quickly put in place and screwed on tight.

As the liquid nitrogen in the bottle boils, the balloon inflates. The audience quickly recognizes that at the observed rate of inflation, the balloon will not last long. While the eventual rupture of the balloon is in itself no shock, there are a couple surprising details involved. First, the amount of noise produced when the balloon bursts is far greater than what would ordinarily be expected, therefore the audience should be warned beforehand so that they may properly cover their ears. The large amount of noise produced results because the lower half of the balloon has been frozen by this point, so that the balloon actually shatters rather than simply bursting. Evidence for this breakage can be shown to the audience afterwards in the form of the shredded, rather than ripped, remnants of the balloon. Secondly, and perhaps most pleasingly, immediately upon the balloon bursting, a fountain of liquid nitrogen and condensing water vapor shoots into the air above the bottle, typically to heights of one to two meters above the bottle opening. It is explained to the audience that as the liquid nitrogen boils and gaseous nitrogen fills the balloon, the pressure over the contents of the bottle increases. Once the balloon bursts the pressure over the remaining liquid nitrogen is decreased rapidly, which increases the rate of boiling. The sudden increase in boiling ejects the liquid nitrogen from the bottle, creating the fountain effect.

Hazards

When dealing with cryogenic liquids proper safety procedures *(7)* should always be followed: wearing eye protection, working in a well-ventilated area, avoiding skin contact, and the use of a plexiglass shield placed between the bottle and the audience, and the bottle and demonstrator. The bottle should be stabilized to ensure it will not tip over. The pop-up top needs to be modified to prevent any accidental closure: a piece of 14-gauge copper wire should be wrapped below the pop-up piece while the cap is in the open position. The audience needs to be warned to protect their ears because a large amount of noise will be produced when the balloon bursts.

Notes

1. Official Water Grenade Balloons are produced by the National Latex Products Company, Ashland, OH 44805. If this type of balloon cannot be found, biodegradable Aqua Sling Water Balloons (The Fun Company, P.O. Box 600404, San Diego, CA 92160) work just fine and are less expensive at $4 per gross.

Literature Cited

1. Nolan, W. T.; Thaddeus, J. *J. Chem. Educ.* **1996,** *73,* 651–653.
2. Coppola, B. P.; Hovick, J. W.; Daniels, D. S. *J. Chem. Educ.* **1994,** *71,* 1080.
3. Lothrop, K. H. *J. Chem. Educ.* **1978,** *55,* 531–532.
4. Kagan, D.; Buchholtz, L. *Phys. Teach.* **1995,** *33,* 150–157.
5. Miller, J. S. *Physics Fun and Demonstrations;* Central Scientific Company: Chicago, 1974.
6. University of Minnesota, School of Physics and Astronomy. *(a) http://www.physics.umn.edu/groups/demo/old_page/demo_gifs/1H11_30.GIF* (accessed July 2002)*;* (b) *http://www.physics.umn.edu/groups/demo/old_page/demo_gifs/4C30_35.GIF* (accessed July 2002).
7. Reider, R. *J. Chem. Educ.* **1970,** *47,* A473.